



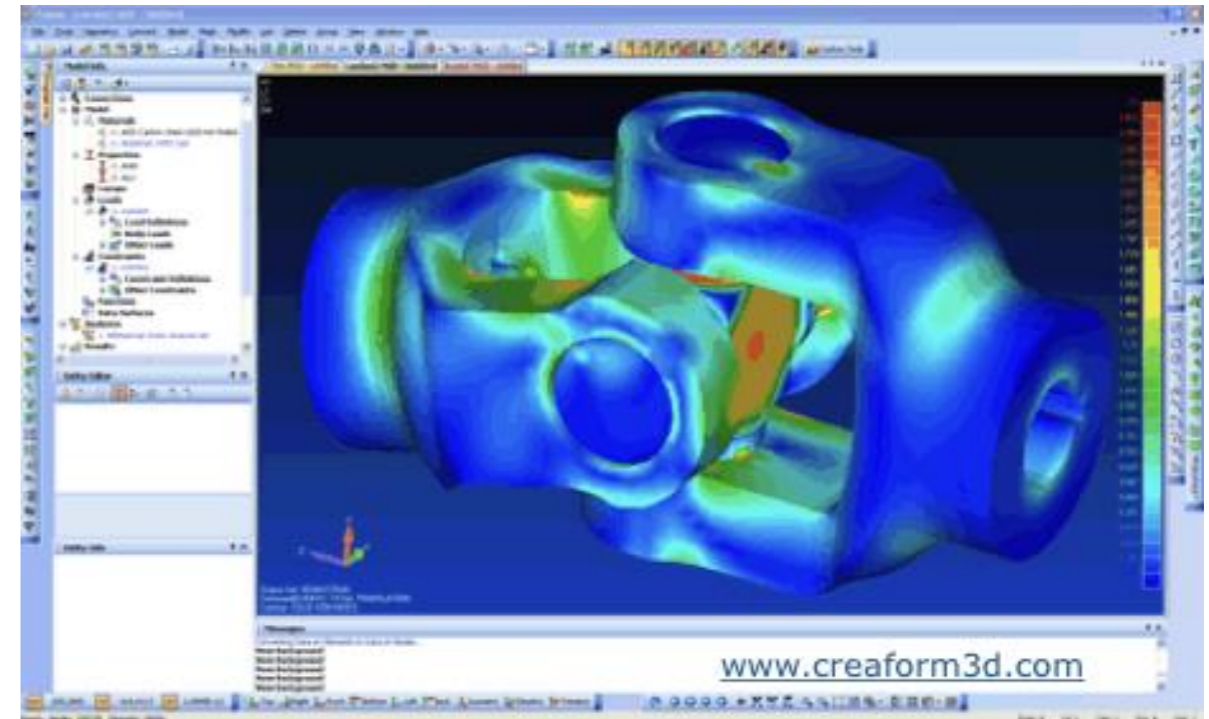
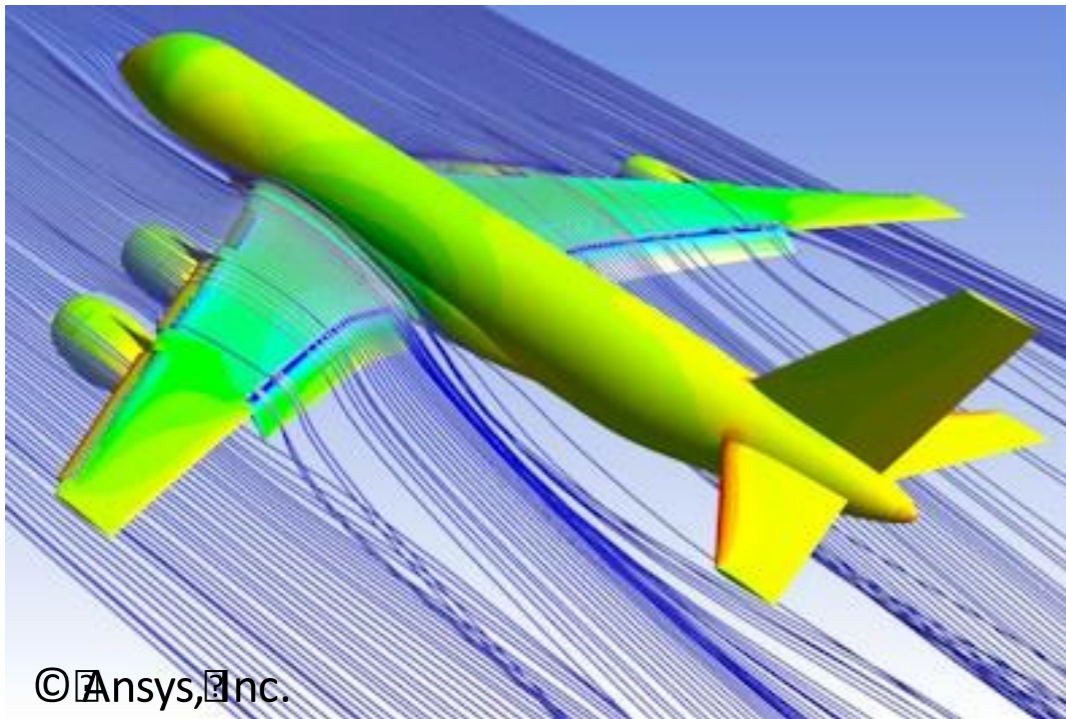
Integration of LiDAR scanning data and 3D crop models
for the development of computer-aided vineyard design
and management tools

Brian Bailey

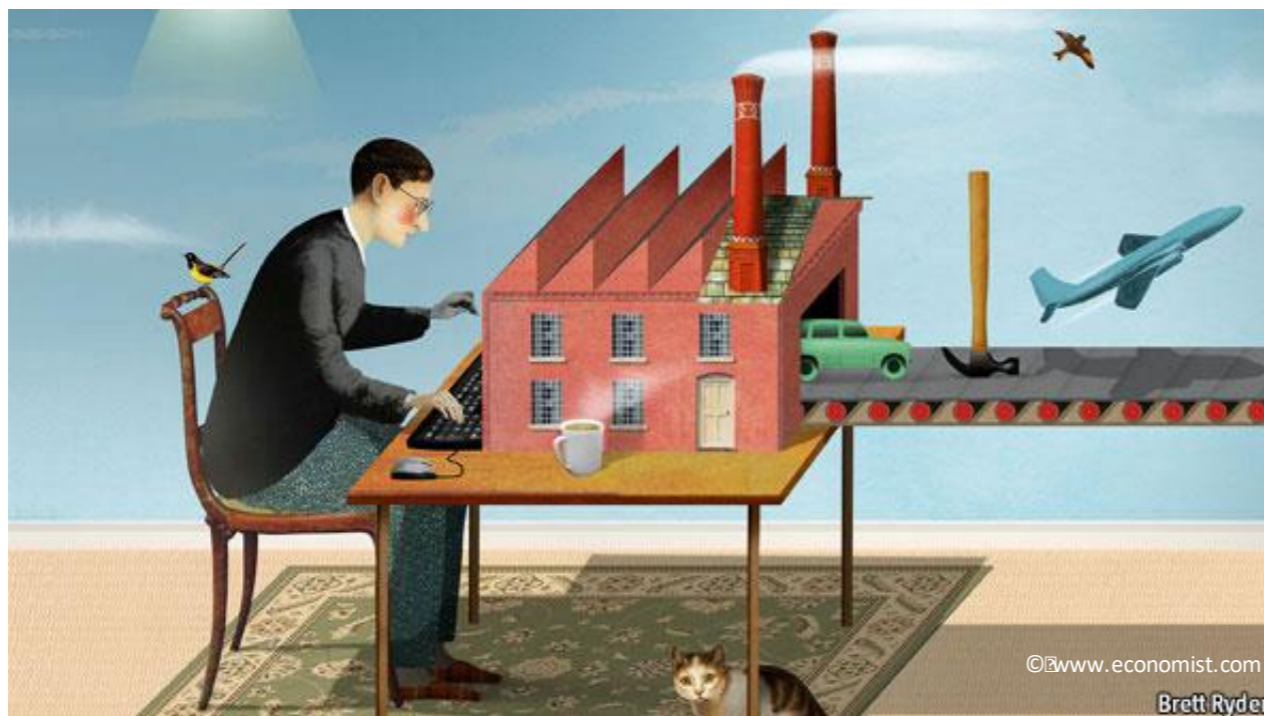
Assistant Professor
Dept. Plant Sciences
University of California, Davis



Engineering Computer-Aided Design (CAD)



The “Third Industrial Revolution”



Scan-To-CAD



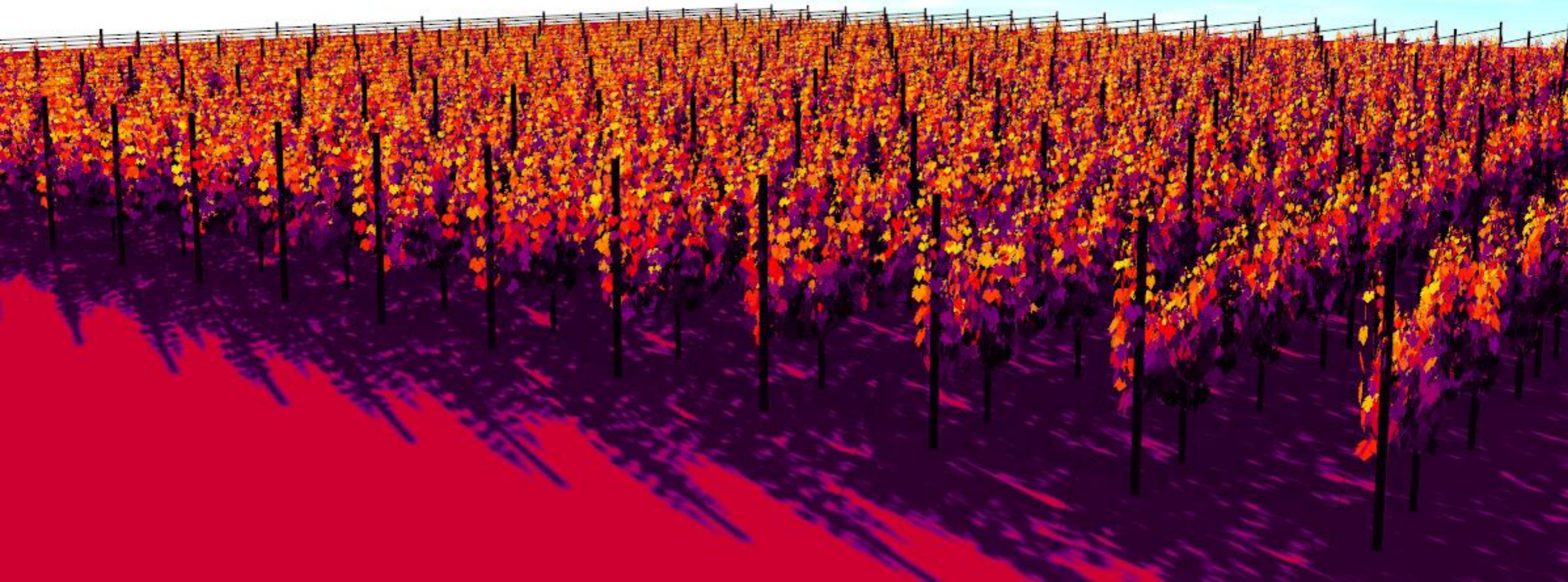
Faro Design ScanArm

Computer-Aided Design (CAD) Computer-Aided Management (CAM)

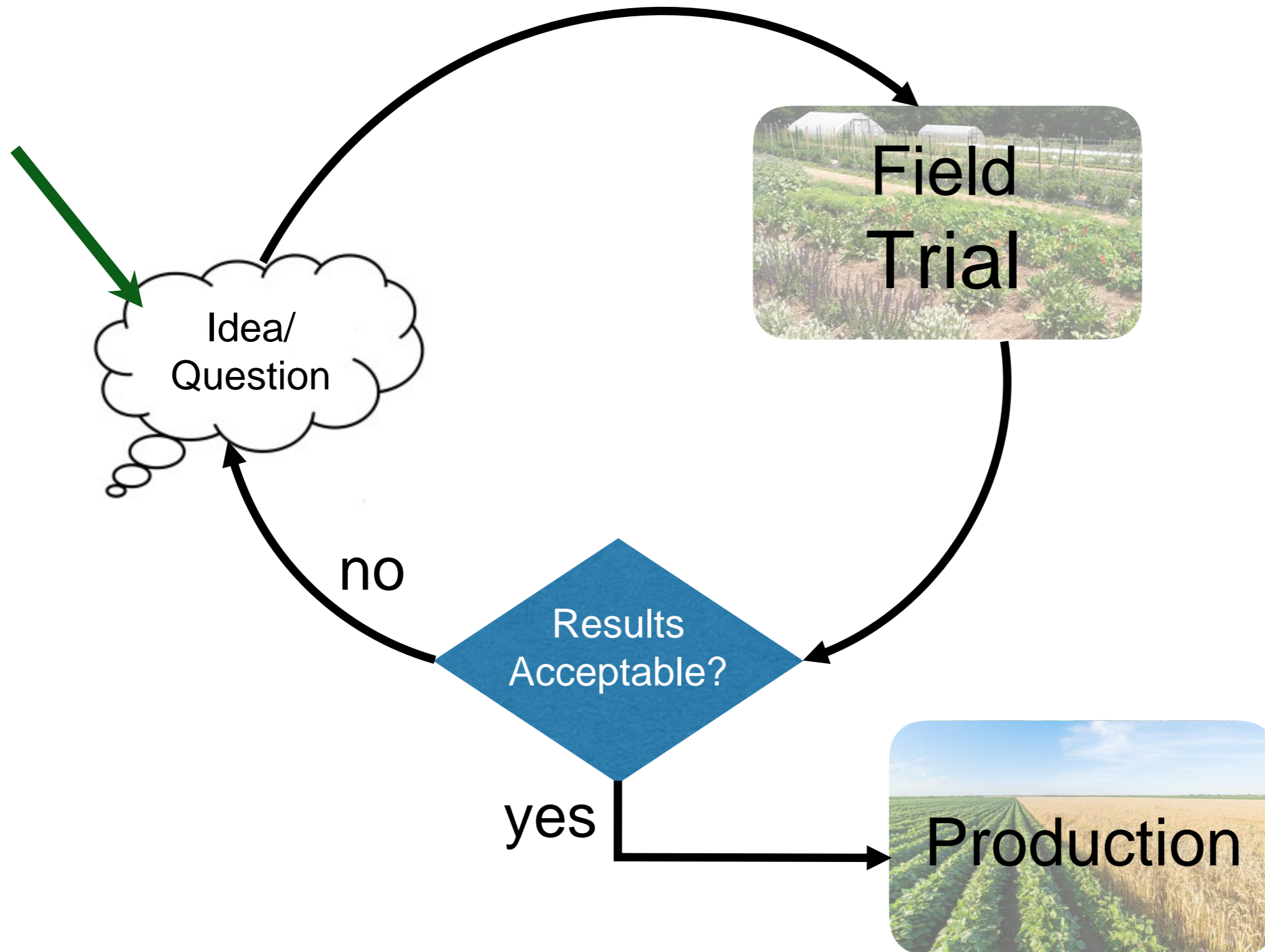
HELIOS



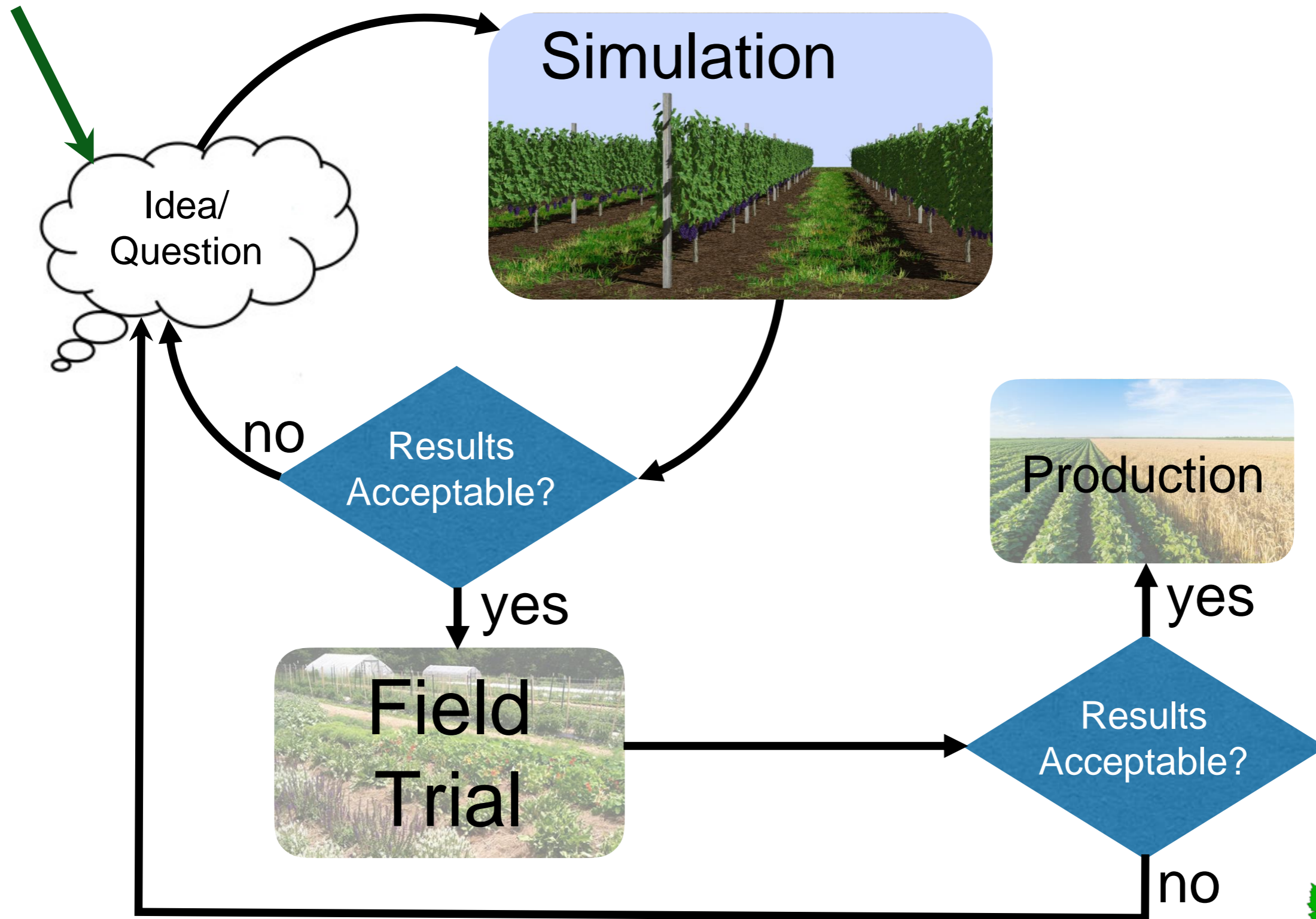
The overall goal is to be able to robustly simulate any possible crop design or management decision.



Traditional Innovation Cycle



Model-Based Innovation Cycle



Continuum of Models

Need lots of data

Need less data

Don't necessarily have to understand what's going on

Need to understand processes and mechanisms



Fully
Empirical

Fully
Mechanistic

Helios 3D Modeling Framework

Available model plug-ins:

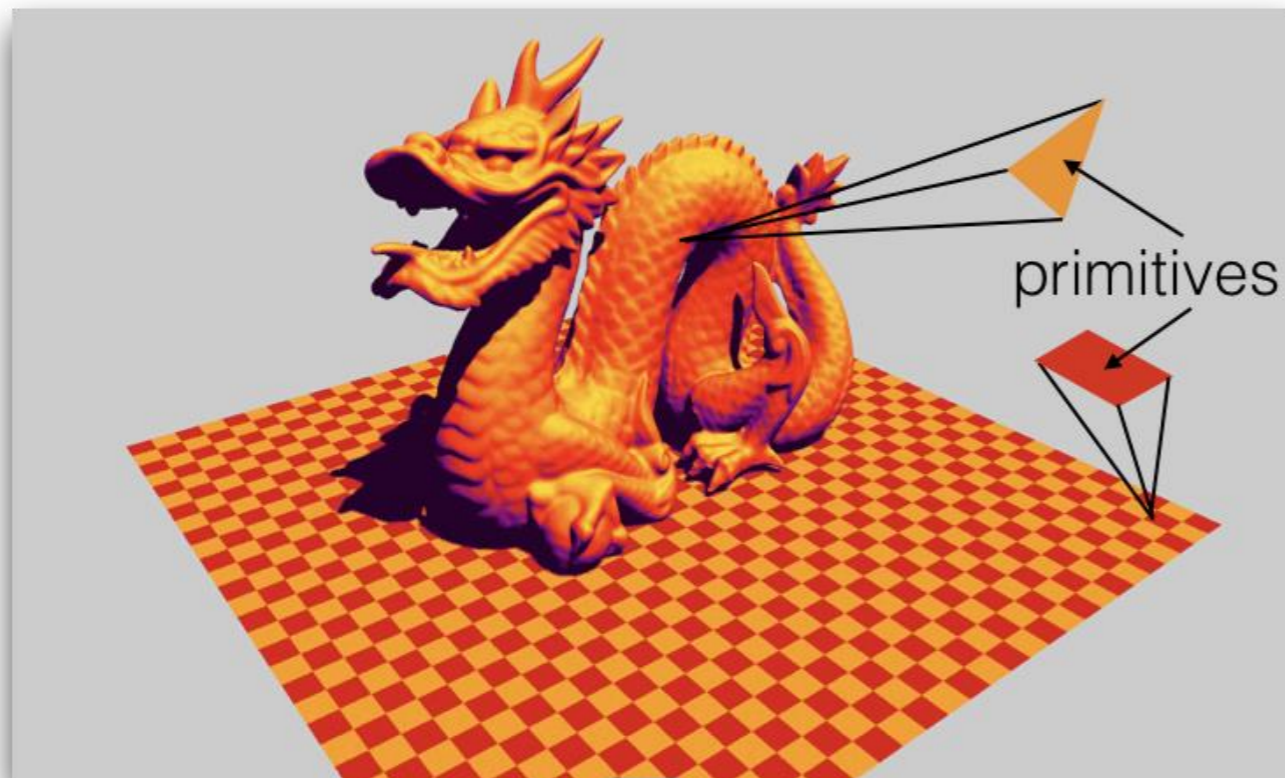
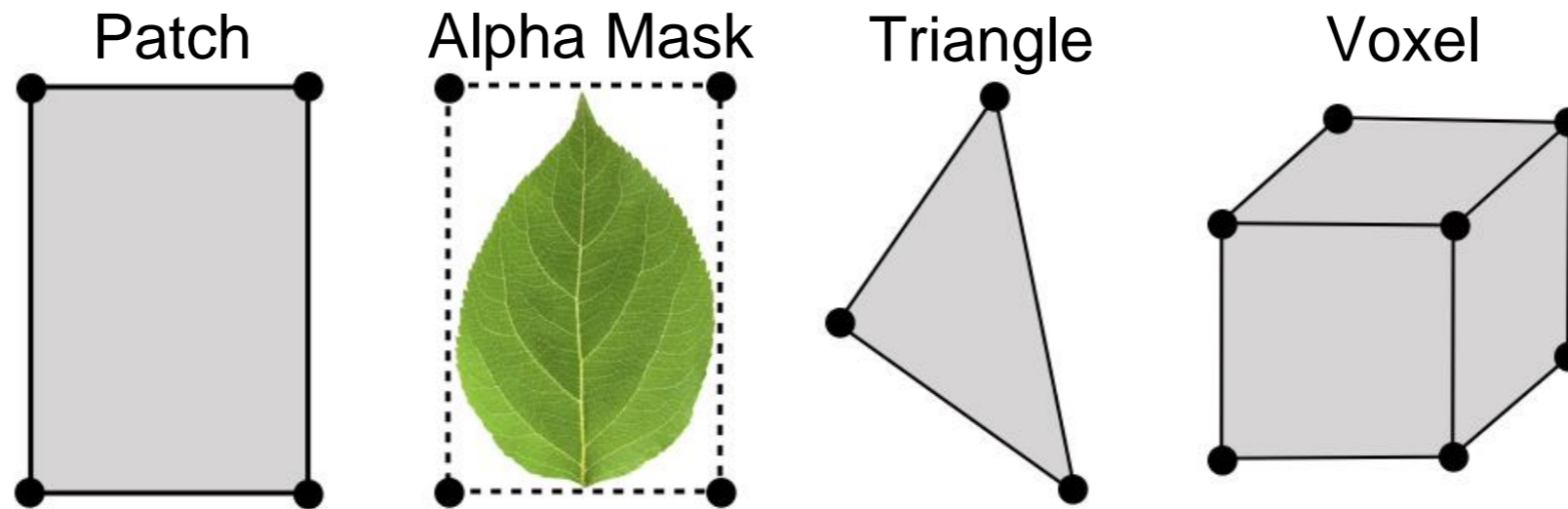
- LiDAR (structural models)
- Radiation
- Microclimate
- Evapotranspiration
- Photosynthesis
- Soil transport
- Others

HELIOS



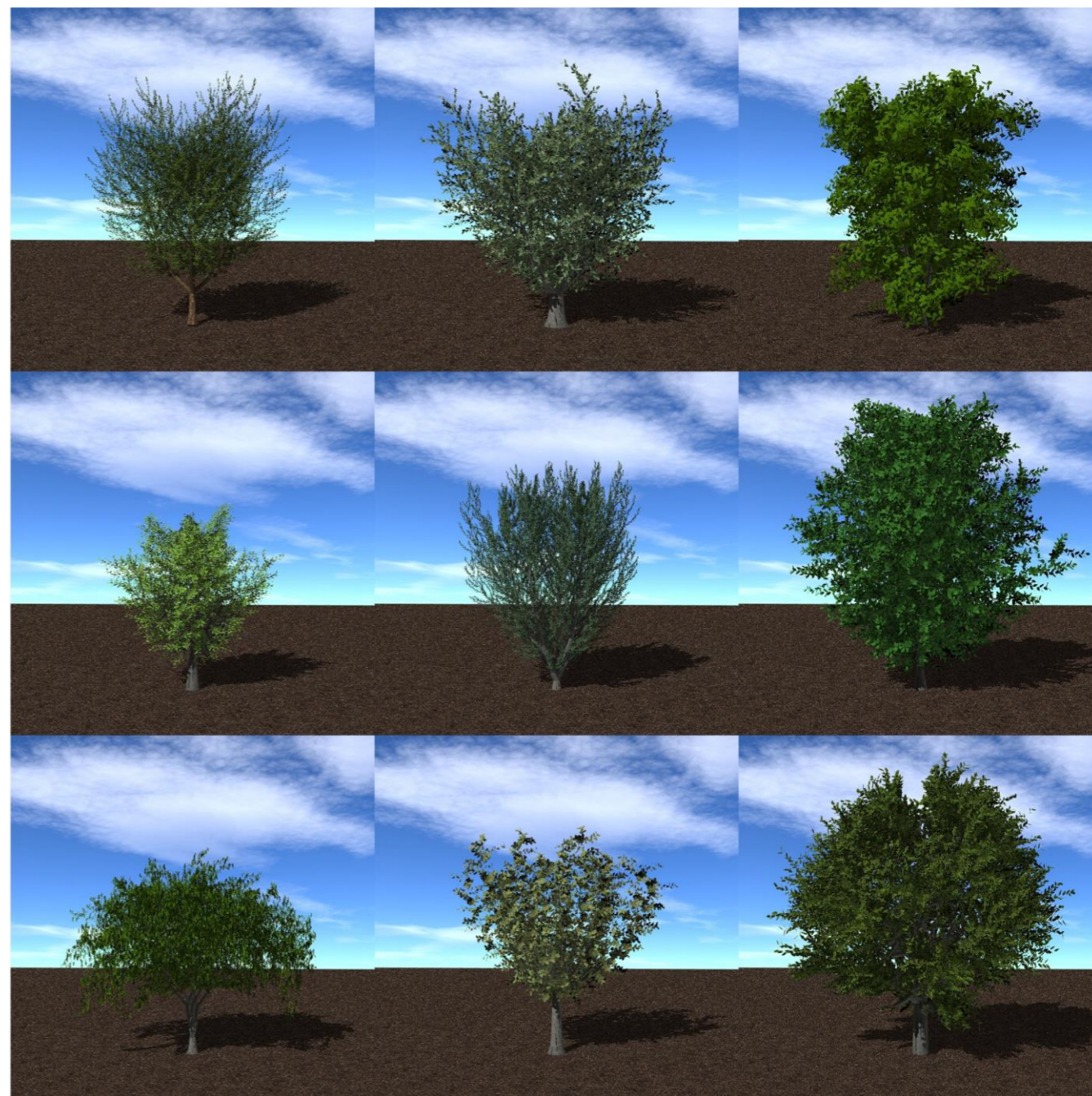
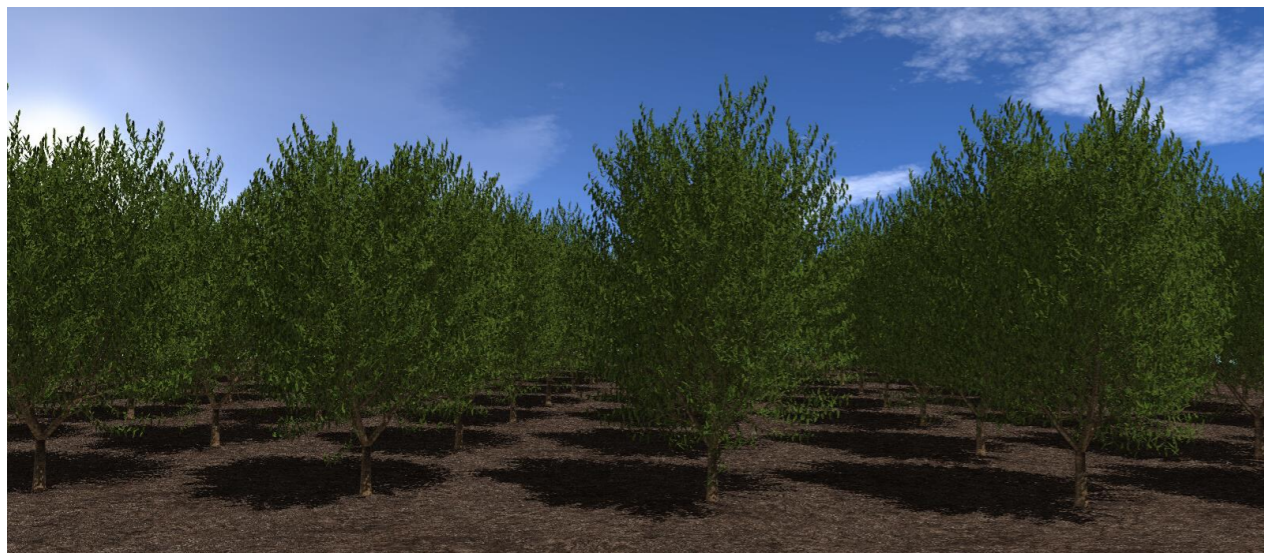
Helios 3D Modeling Framework

Representation of geometry: Primitive Elements



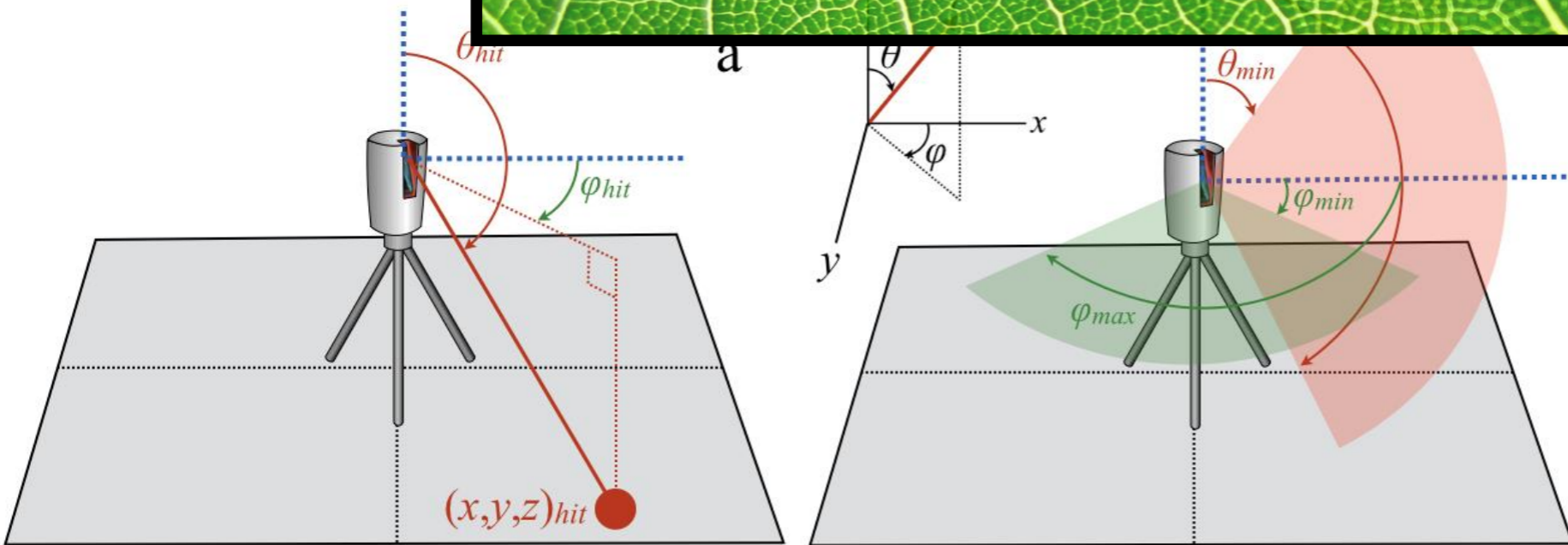
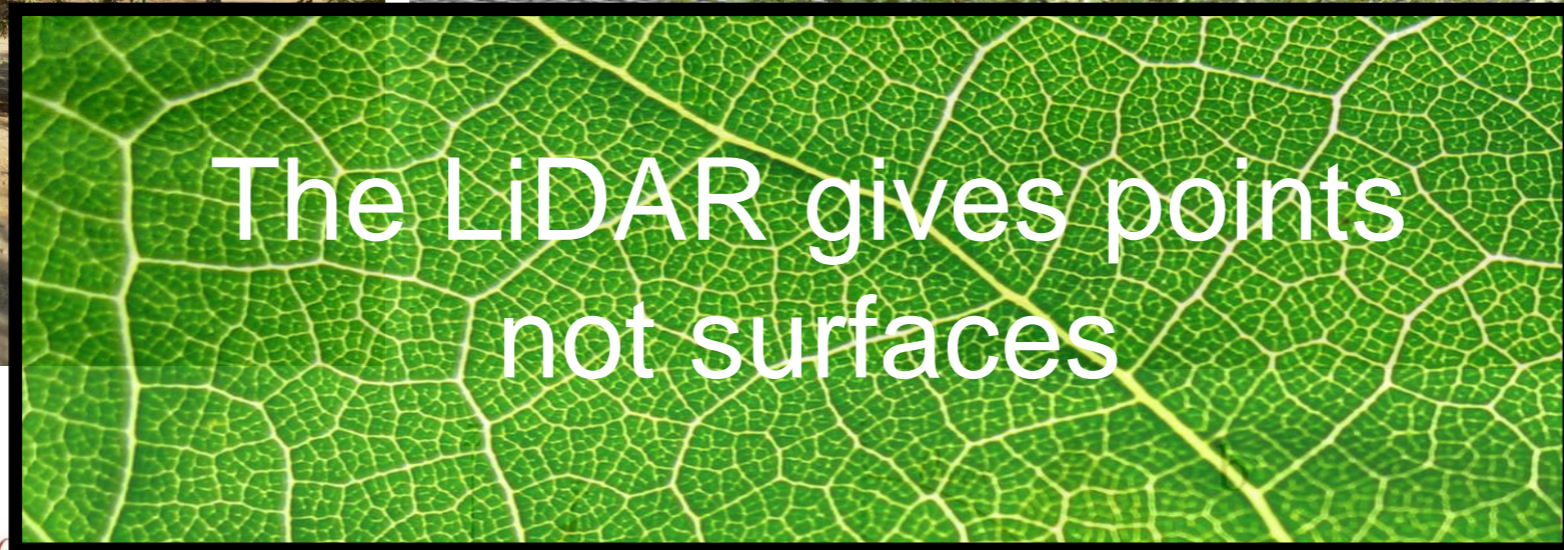
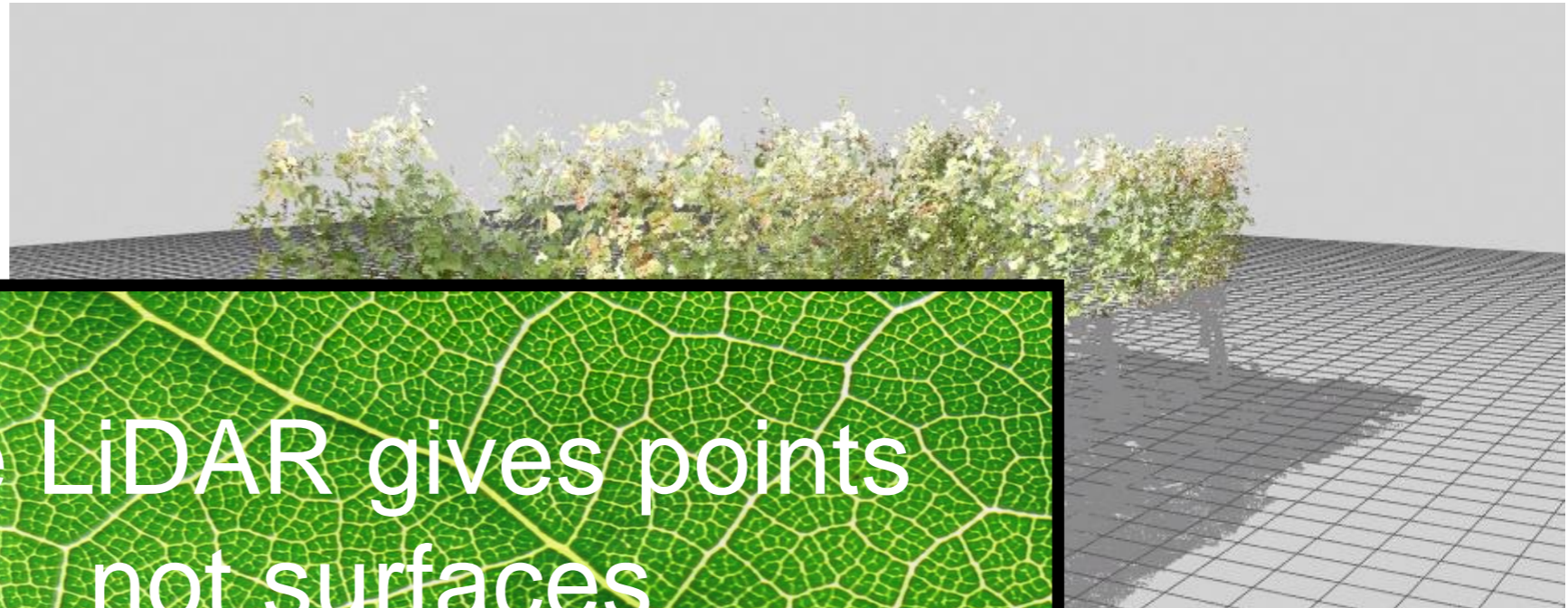
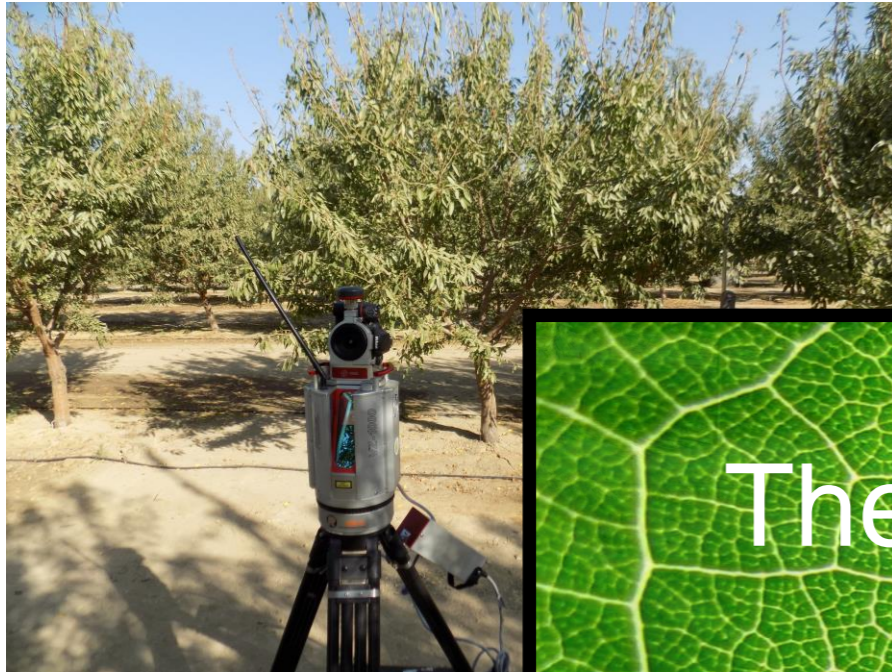
3D Inputs

3D Structural Model



Rapid Measurement of Canopy Structure

Terrestrial LiDAR Scanning



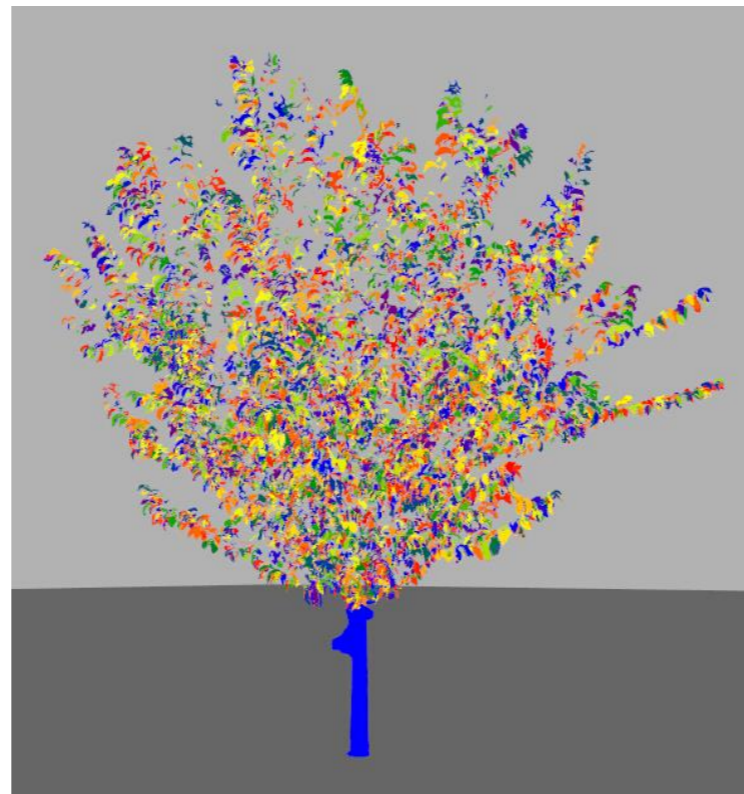
Canopy reconstruction at the leaf level

Leaf-by-leaf reconstruction from LiDAR data to provide structural inputs for the 3D models.

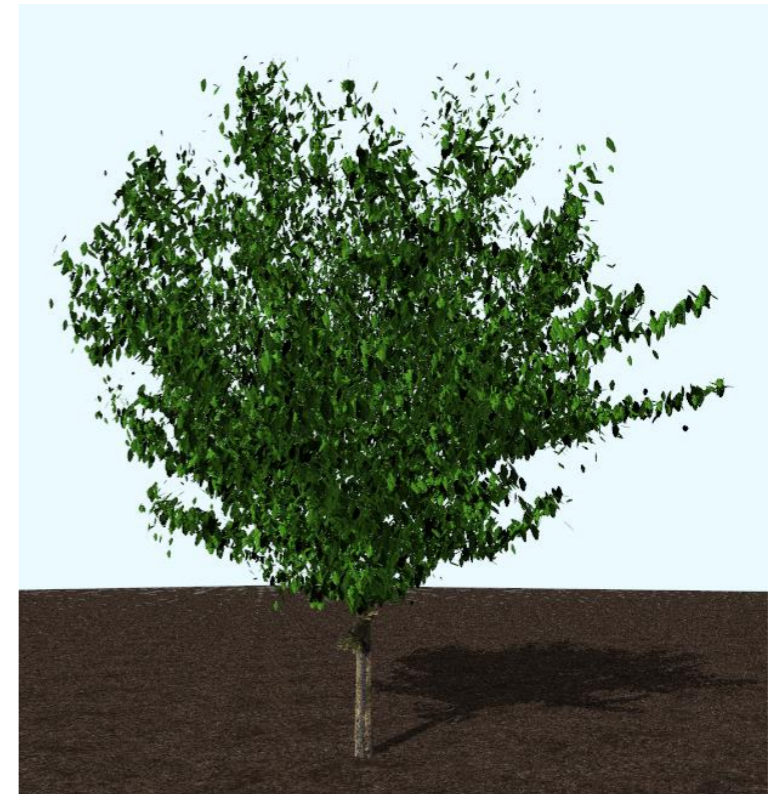
actual photo



leaf segmentation

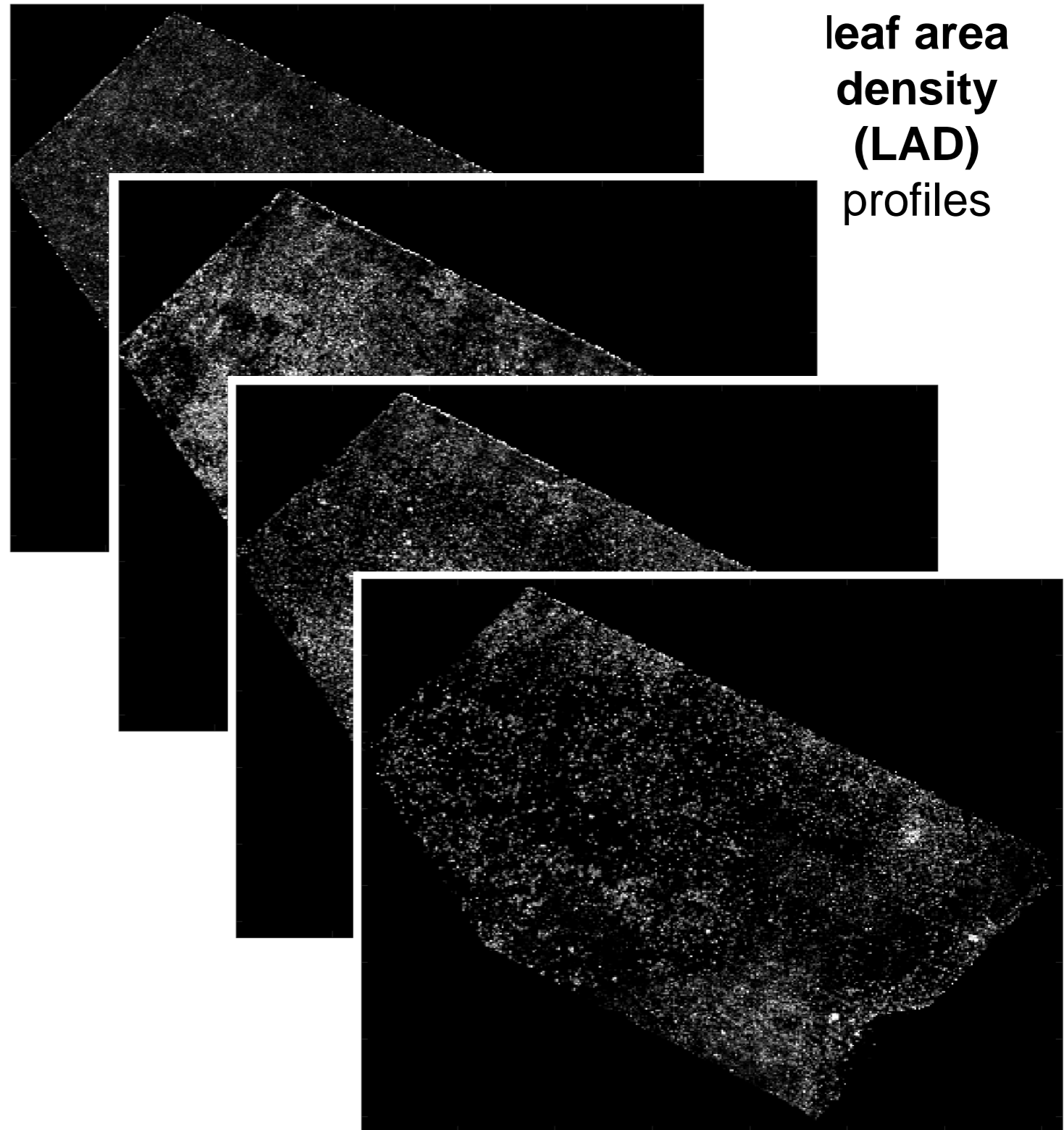
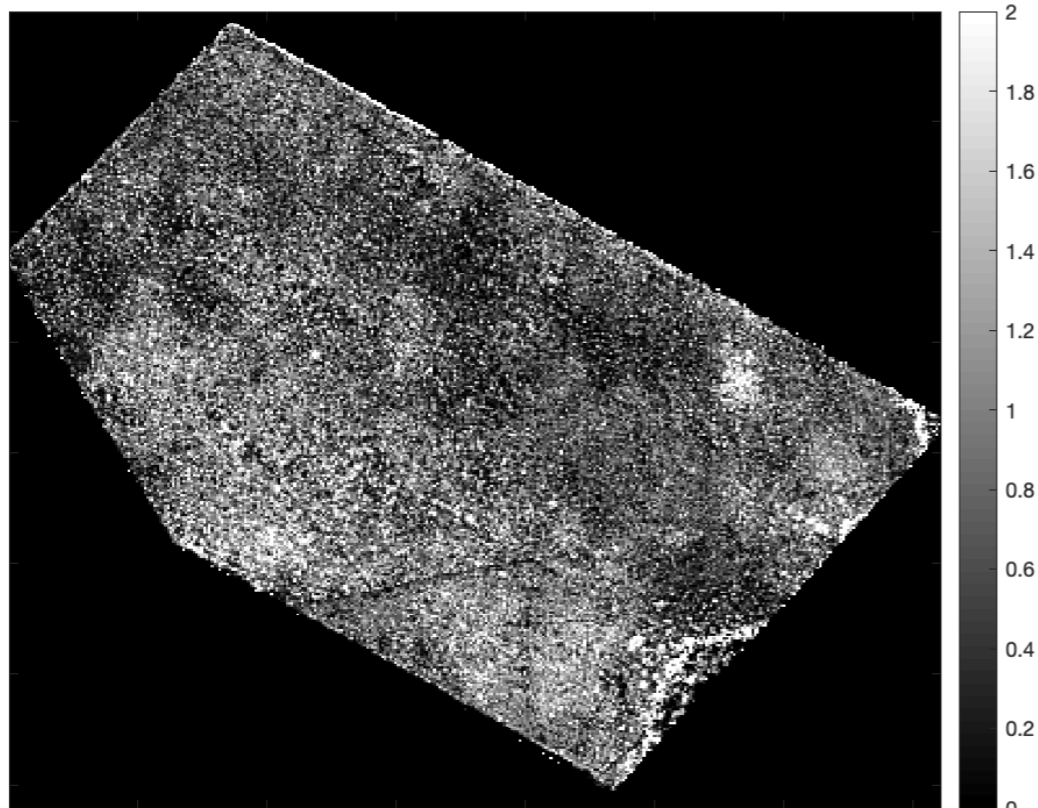


reconstruction



Airborne LiDAR scanning

leaf area index (LAI)



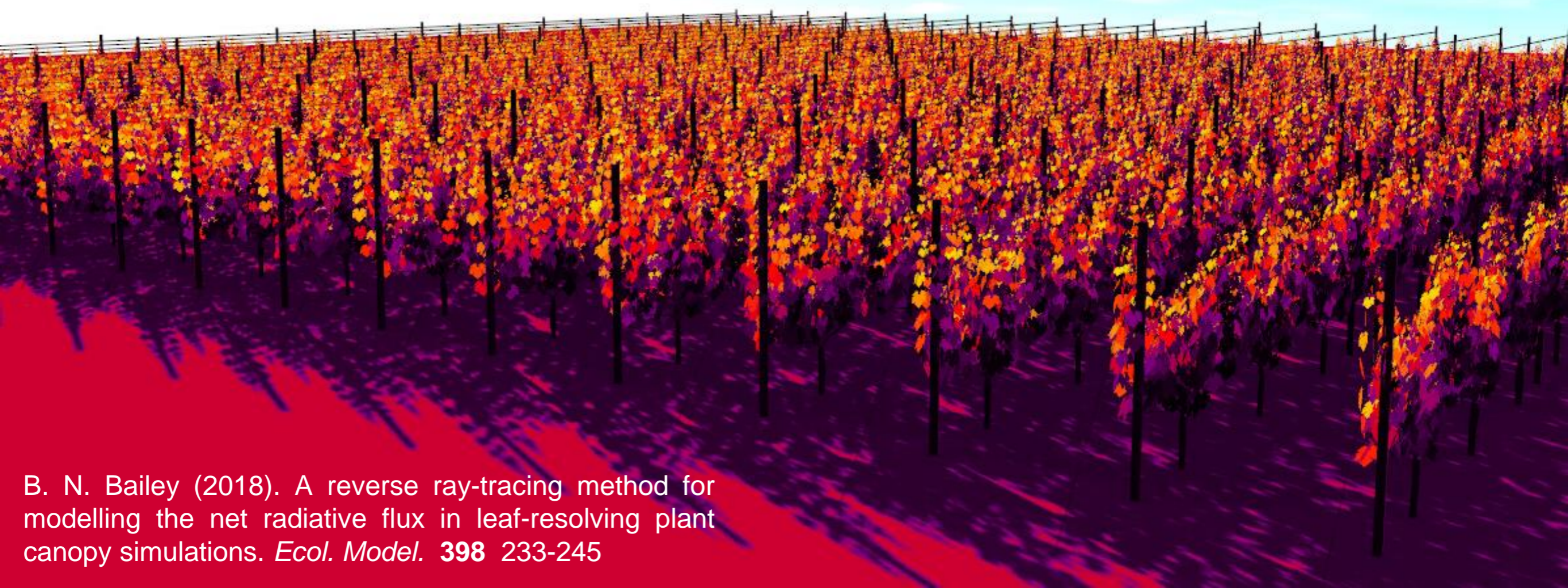
leaf area density (LAD) profiles

Light Model Plug-In

HELIOS



- 3D raytracing-based model of shortwave and longwave radiation transport
- New backward raytracing method allows for efficient and accurate modeling, particularly for longwave emission.



B. N. Bailey (2018). A reverse ray-tracing method for modelling the net radiative flux in leaf-resolving plant canopy simulations. *Ecol. Model.* **398** 233-245

Computational Cost

single CPU



supercomputer

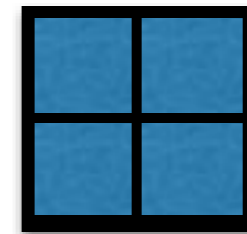




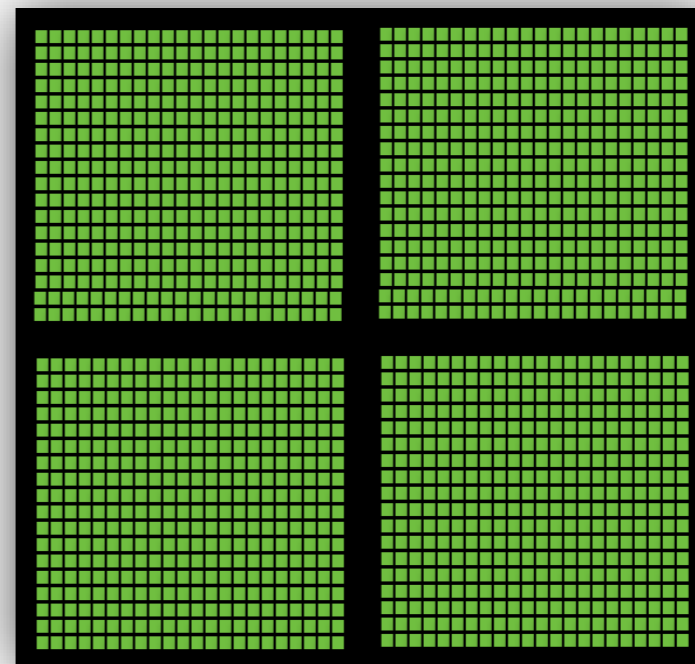
Image Credit: Activision, Sledgehammer Games

Efficient Scaling from Leaf to Canopy

GPU Acceleration



CPU
2-6 cores



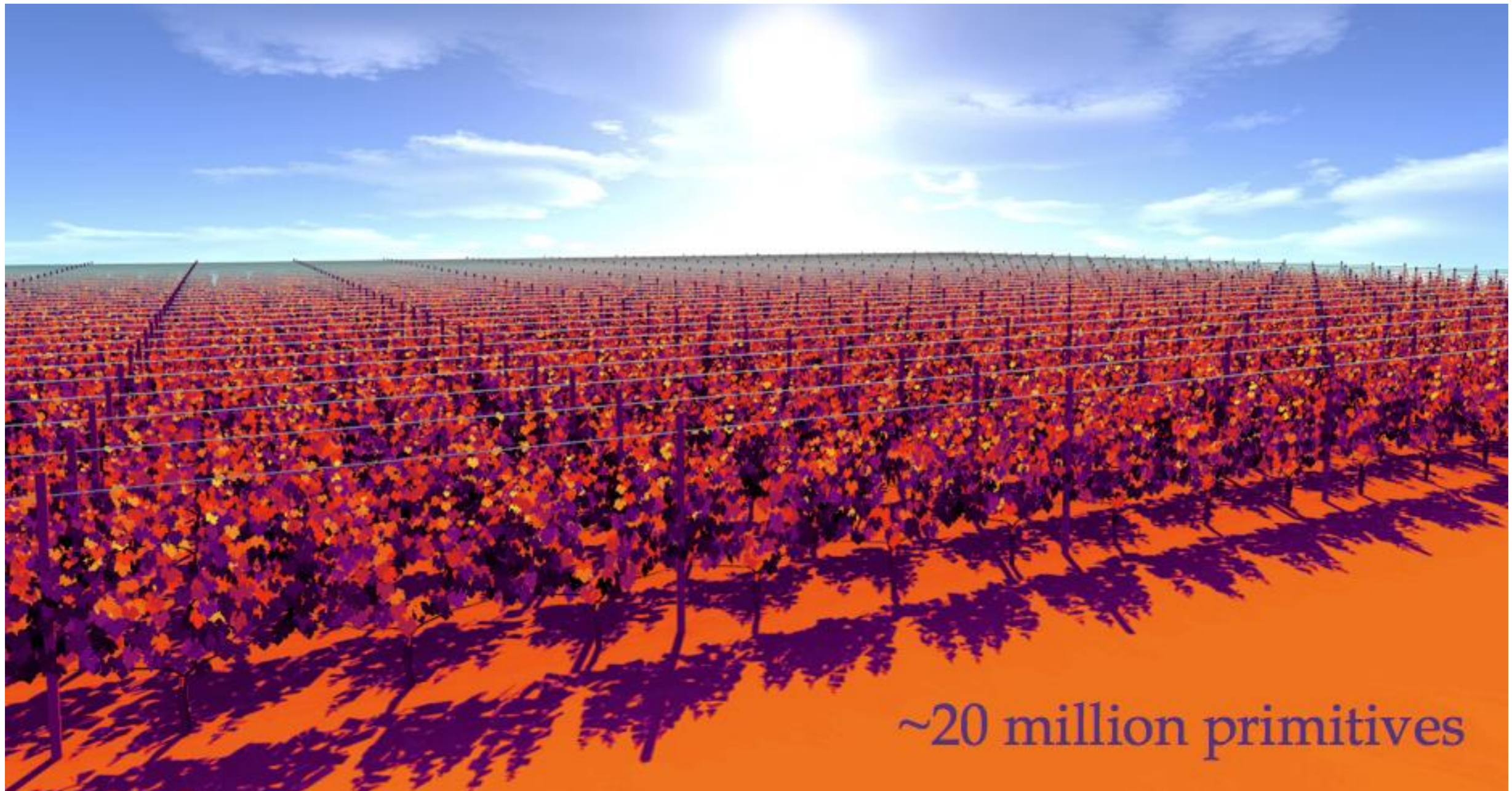
GPU
thousands of cores



NVIDIA® OPTIX™
RAY TRACING ENGINE



Efficient Scaling from Leaf to Canopy



Unparalleled combination of size and complexity.

Test Case: Orchard Evapotranspiration

- Riegl VZ-1000 waveform LiDAR scanner
- 27 scans total, each takes couple of minutes
- Each scan about 8M points

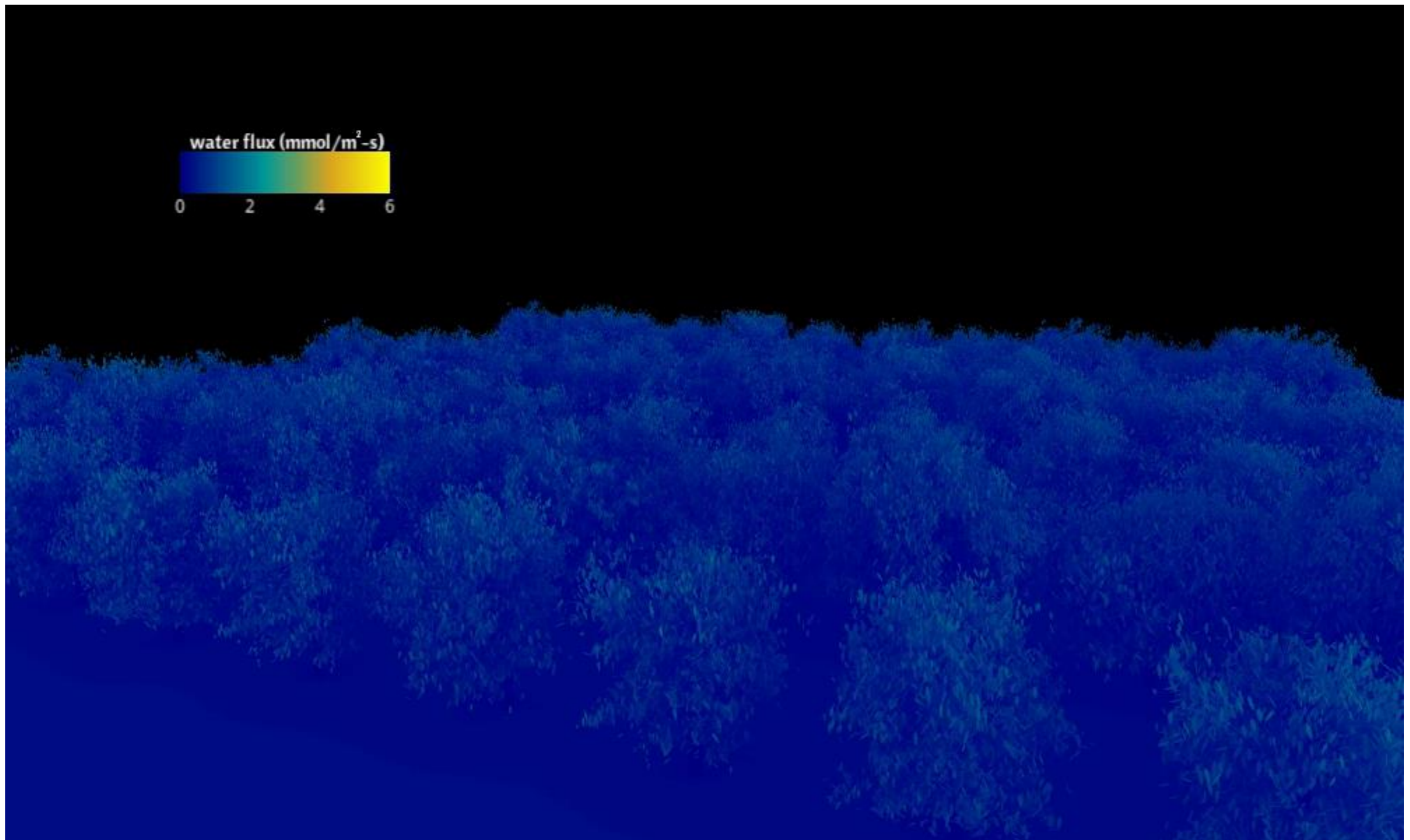


Test Case: Orchard Evapotranspiration

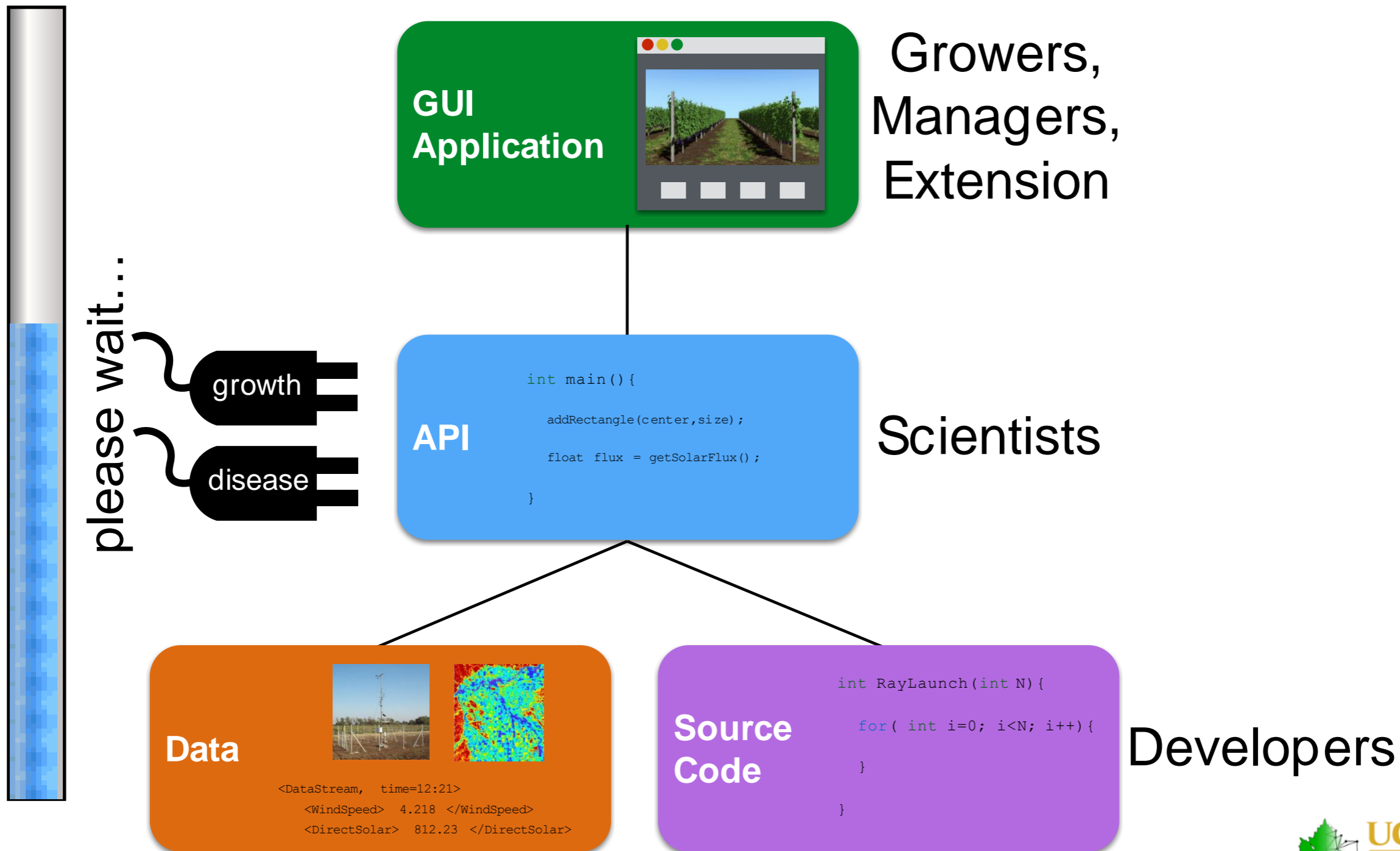
- LI-COR LI6800 portable photosynthesis system
- Measured full stomatal response to light, temperature (dark/saturated light), and humidity (dark/saturated light) for only a few leaves
- Used data to parameterize stomatal conductance model



Test Case: Orchard Evapotranspiration



Tech Transfer Pipeline

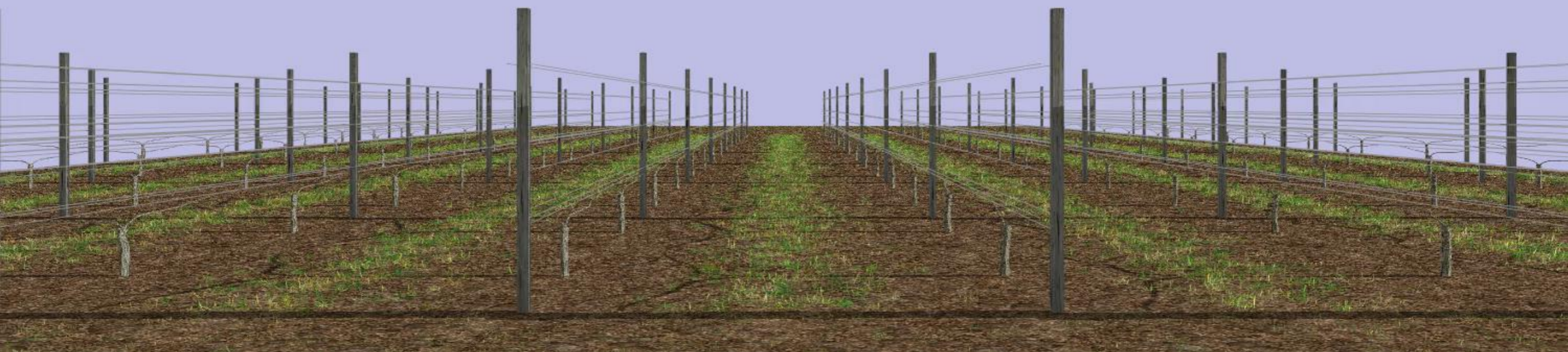


Ongoing Research Projects

Modeling Powdery Mildew Spread

 - Deposited Spore

 - Infected Leaf

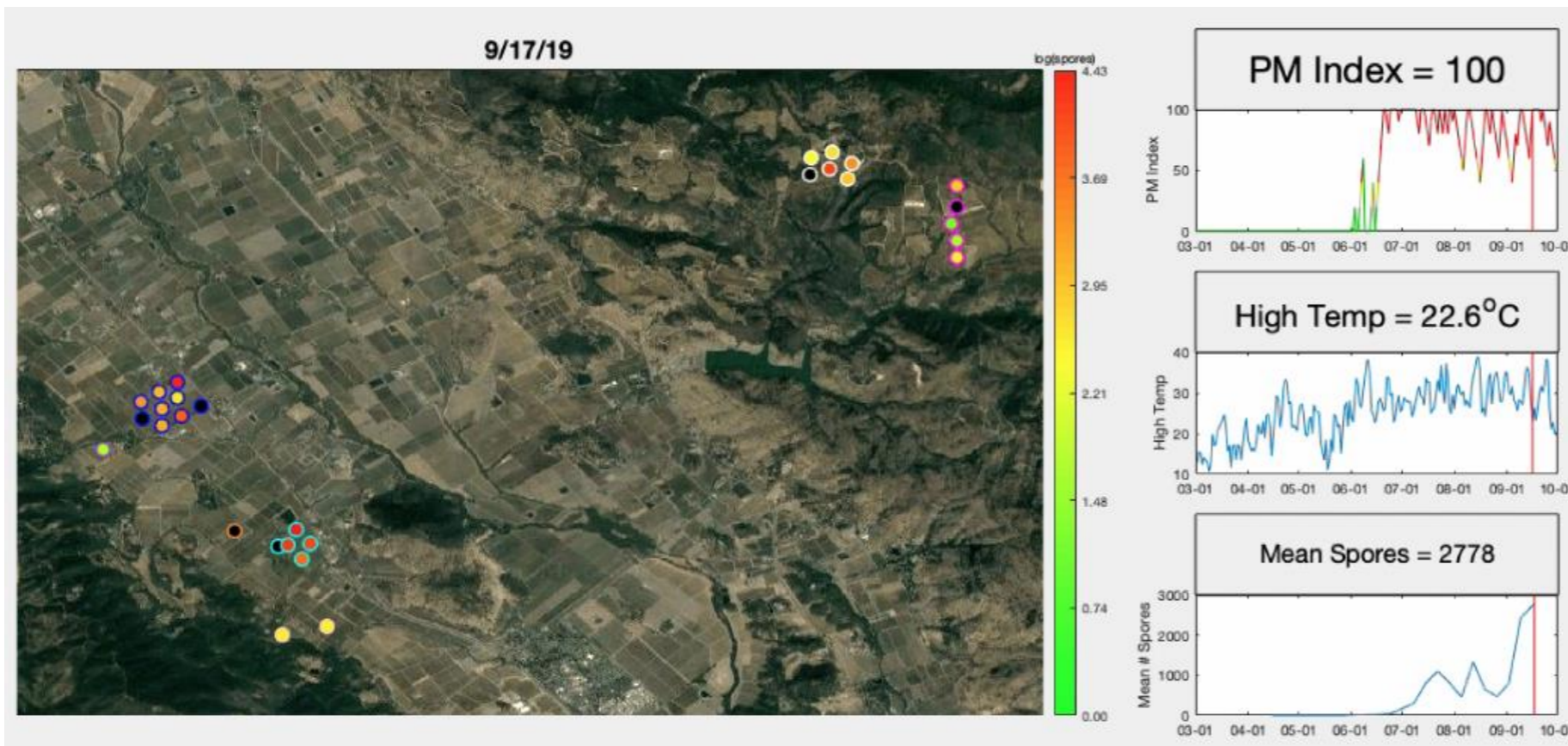


Collaborators:
Walt Mahaffee, USDA-ARS; Monica Cooper, UCCE Napa

Ongoing Research Projects

Simple Models for Powdery Mildew Management

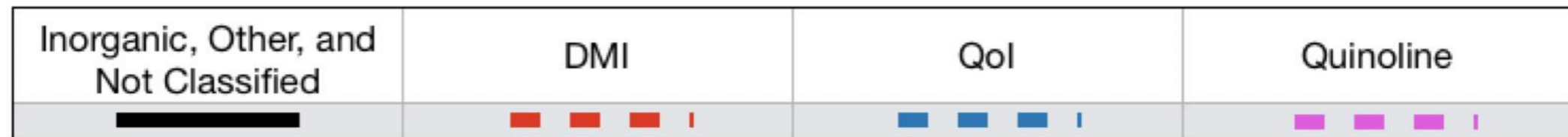
rotorod traps



Collaborators:
Walt Mahaffee, USDA-ARS; Monica Cooper, UCCE Napa

Ongoing Research Projects

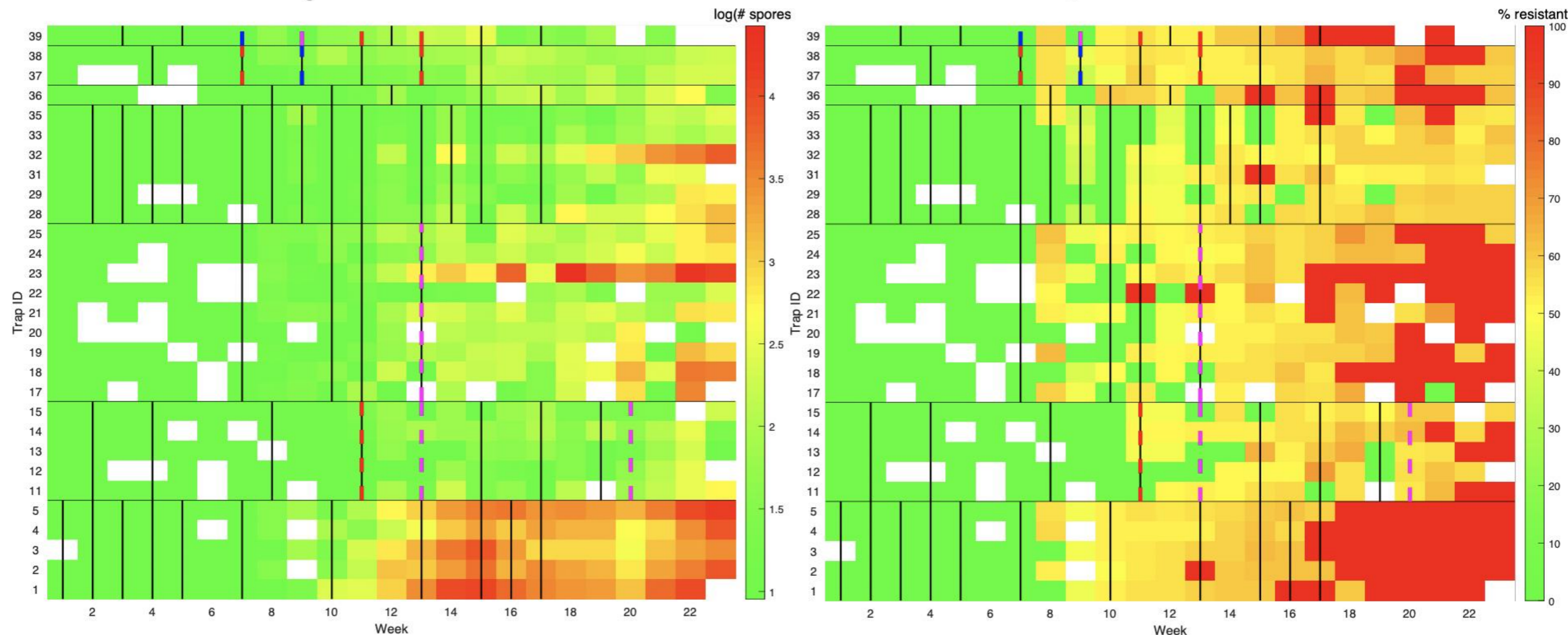
Spore Trap Data from 2018



site
7
6
5
4
3
2
1

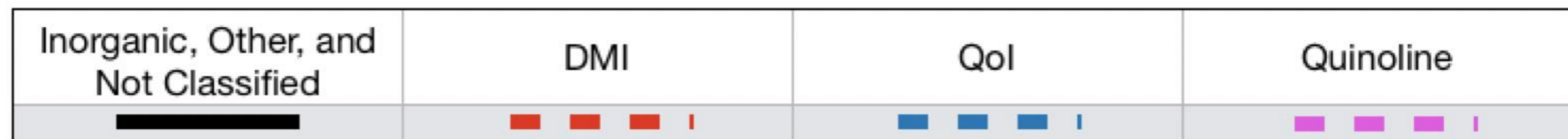
Spore Count

Qol Resistance



Ongoing Research Projects

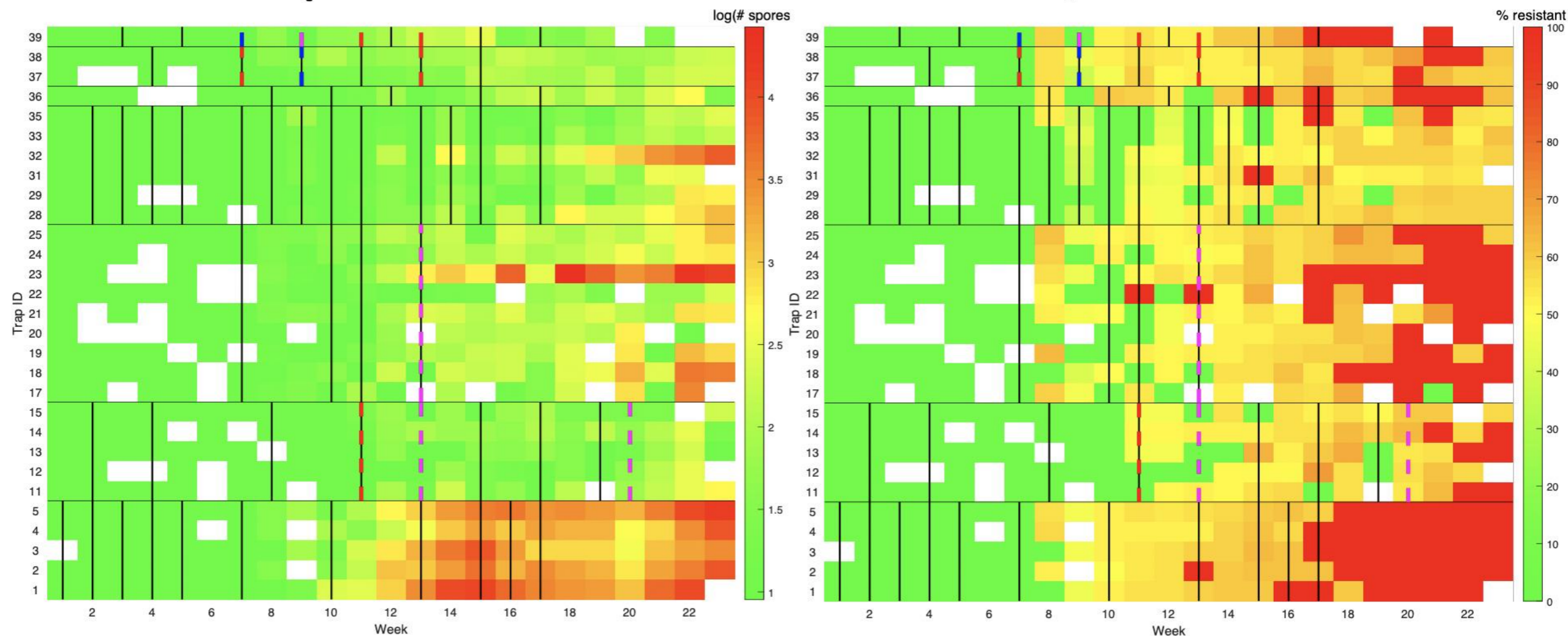
Spore Trap Data from 2019



site
7
6
5
4
3
2
1

Spore Count

Qol Resistance



Ongoing Research Projects

Improved models of growth (both rates and structure)

...and fruit development



4/21/2014 09:00

Ongoing Research Projects

AgRISCS Project: Management simulation tool to better understand how growers utilize data, models, and their perceptions of risk to make decisions.



Thank You!

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web: baileylab.ucdavis.edu



www.github.com/PlantSimulationLab/Helios

Financial Support:

