

Decision Support Tools: Modeling Plant X Environment Interactions For Improved Management



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Gainesville, FL

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Reduce Crop Losses by using Crop Models to Improve (Genetic) Environment X Management—

Georgia peach crop loss a multi-million dollar disaster for farmers

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People shopping for summer fruits may notice peaches are selling for higher prices.

A double whammy of unexpected weather destroyed most of the peach crop in the Southeast.

Last month, wholesale prices for a case of Georgia peaches reported 100 percent, from roughly \$20 to about \$30.

“Unseasonably warm temperatures deprived the crop of needed “chill hours,” followed by freezing temperatures in mid-March that stretched across the Southeast.”

CBS NEWS / June 22, 2017, 8:24 AM

Science for Environment Policy

Climate change threatens early-flowering plants due to lack of snow

10 June 2016 Issue 458 Subscribe to free weekly News Alert

Source: Gezon, Z., Inouye, D. & Irwin, R. (2016). Phenological change in a spring species: implications for pollination and plant reproduction. *Global Change Biology*, 22(5): 1779–1793. DOI: 10.1111/gcb.13209

Contact: zak.gezon@disney.com

Read more about: Agriculture, Biodiversity, Climate change and energy

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The researchers manipulated flowering in two ways. Both experiments were conducted in the subalpine meadows in Colorado, USA. First, they removed snow from an area where the subalpine meadows in Colorado, USA. First, they removed snow from around 10 days earlier. These plants grow to induce earlier flowering when snow has occurred around 10 days earlier. These plants were more likely to experience frost damage, which led to low reproduction rates. Even when supplemental pollen was provided, the frost-damaged plants could not recover their reproductive output.

This study investigated both possibilities. The researchers experimentally altered the timing of flowering and observed the effects on plant-pollinator interactions and the reproductive output of flowers. The results showed that the timing of flowering influenced the timing of frost damage and the survival of the plants. The researchers manipulated flowering in two ways. Both experiments were conducted in the subalpine meadows in Colorado, USA. First, they removed snow from around 10 days earlier. These plants grow to induce earlier flowering when snow has occurred around 10 days earlier. These plants were more likely to experience frost damage, which led to low reproduction rates. Even when supplemental pollen was provided, the frost-damaged plants could not recover their reproductive output.

Farmers and gardeners need to know the schedule of plant and insect development to decide when to plant (and harvest) to avoid frosts and when to apply fertilizers and pesticides. Many gardeners that I've talked to over the years use phenological correlations to determine planting times, often without even realizing it. They correlate the time of year with the time of common flowering plants. Examples I've heard include planting peas when daffodils bloom; potatoes when the first dandelions bloom; beans, carrots, crucifers (e.g. cabbage, cauliflower, broccoli) when lilacs are in full bloom; beans, cucumbers, and squash when lilac is in full bloom; tomatoes

Climate change shifts strawberry farming

Farmworkers pick strawberries on Fancy Farms in Plant City in February 2015. SKIP O'ROURKE / Times (2015)

The Ledger
Published: July 24, 2017

LAKELAND — Florida strawberry growers already have experienced a dress rehearsal for the impacts of climate change during the past two seasons. "We've had a lot of climate variability in recent years," said Vance Whitaker, assistant professor of strawberry breeding at the University of Florida's Gulf Coast Research and Education Center in Balm. "In the last two strawberry seasons have been test cases for global warming."

"November, the hotter-than-normal weather caused the young plants, pushing the first crop

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NATURE RECREATION HISTORY ARTS ENVIRONMENT FOOD

SATURDAY, MARCH 18, 2017 Arrival of Spring, Phenology and Climate Change

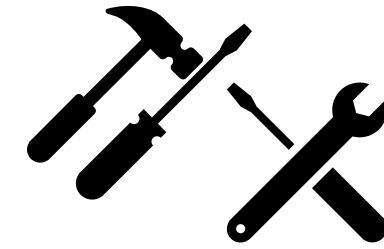
by Richard Gart

How do you know when spring has begun? 3 Comments of maple sap? The first crocuses coming to frame the snow? Ice out on local lakes? The arrival of the first red-winged blackbirds? The flavor of peaches? Apple trees and cherries blooming?

Metacrine-Webster defines phenology, which is derived from the Greek word *phaino*, meaning to appear, as "a branch of science dealing with the relations between climate and periodic biological phenomena in plants and animals such as when insects hatch or arrive, when flowers and plants bloom, birds and insects (e.g. butterflies) arrive, mate or nest and depart, and how all of these function within ecosystems and respond to change."

Farmers and gardeners need to know the schedule of plant and insect development to decide when to plant (and harvest) to avoid frosts and when to apply fertilizers and pesticides. Many gardeners that I've talked to over the years use phenological correlations to determine planting times, often without even realizing it. They correlate the time of year with the time of common flowering plants. Examples I've heard include planting peas when daffodils bloom; potatoes when the first dandelions bloom; beans, carrots, crucifers (e.g. cabbage, cauliflower, broccoli) when lilacs are in full bloom; beans, cucumbers, and squash when lilac is in full bloom; tomatoes

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Plant Breeders and Farmers Need Decision Support Tools

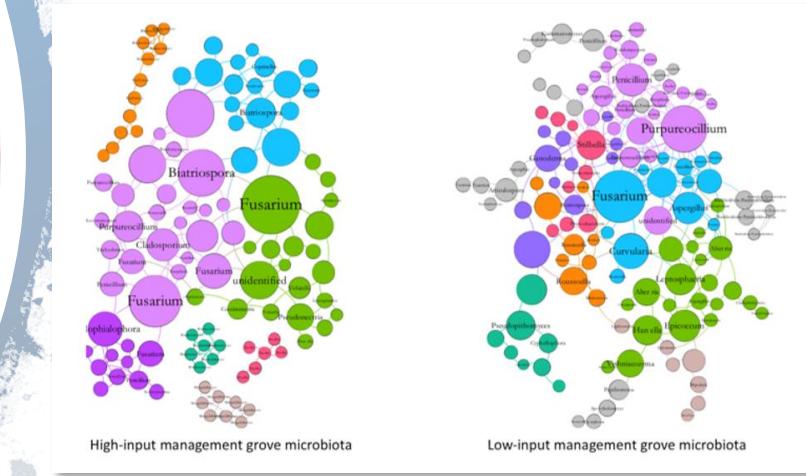


- It takes approximately 10 years for a new genotype of a crop to make it to market.
- As climates change, new crop cultivars (genotypes) need to be created that are adapted to these changes (i.e., the targeted environments).
- Plant breeders need computational tools to design and test new genotypes in targeted environments without running costly experiments.
- Tools to characterize the **environment** are necessary to tease out the plant – environment- soil ecosystem interactions for better management (farm management).

- Improved Sensor Technology*
- Network Models of water-soil-microbe-plant systems*
- Decision Support Models to better manage crops*

Hydroponics (lettuce) – Test Bed for Pathogen Detection and Biotic Controls

(with Drs. Sarah Strauss (UF), McLamore (UF), Gomes (IA), Stutte(SyNRGE LLc))



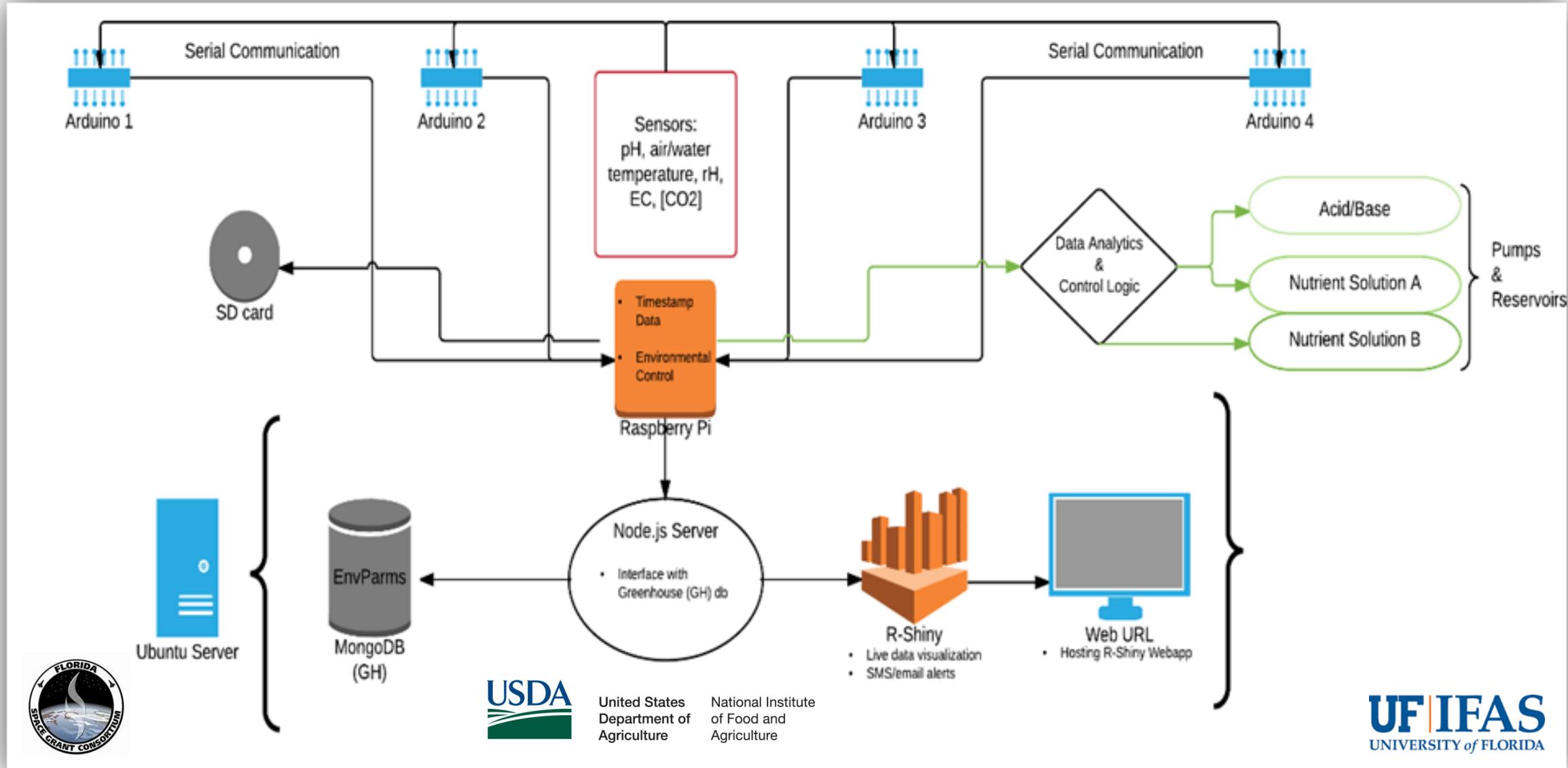
Microbial Community (+/- treatment)
Image Provided Dr. Strauss

Predictive Model of Plant Growth

HydroPatrol – Low Cost (\$500), Online Monitoring and Control System -Sensors

(<https://github.com/EmerickL/HydroPatrol/>),

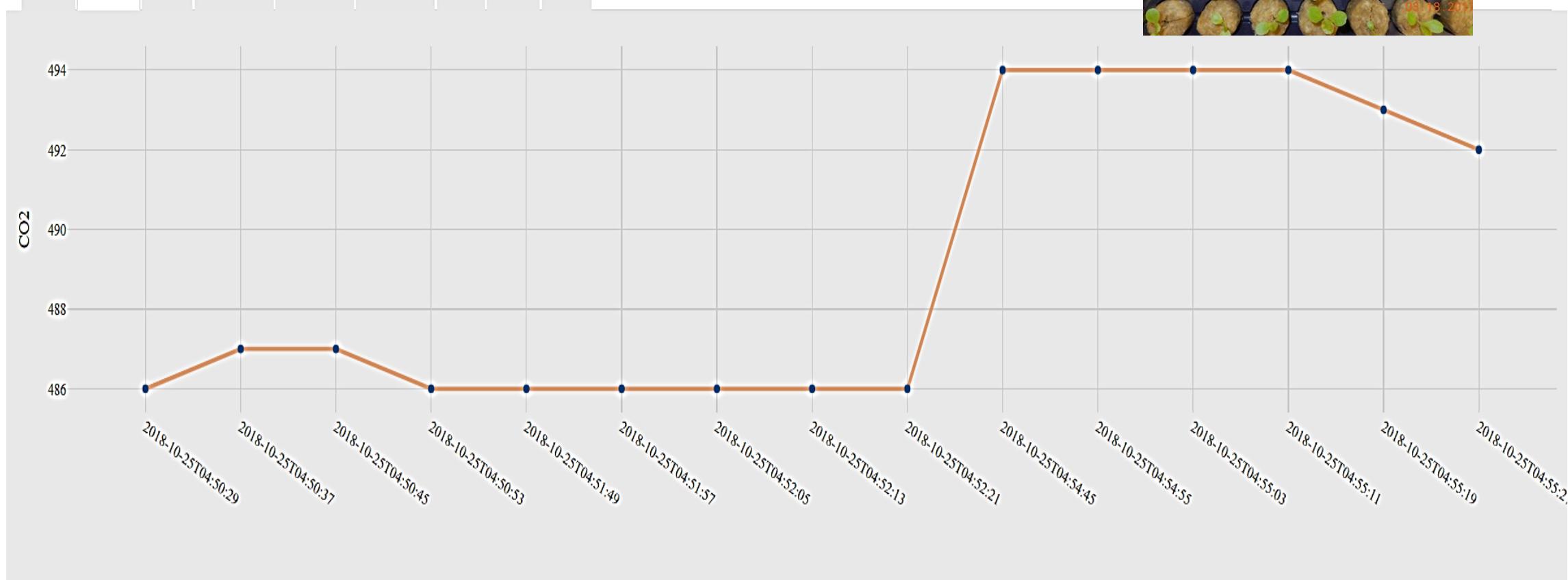
Ph.D. student:
Emerick Larkin



SmartPath - HydroPatrol

Select System

d0 CO2 EC temp3 temp2 temp1 lvl pH rH



Resolution:

10



Minutes Back:

60



**Ph.D. student:
Emerick Larkin**

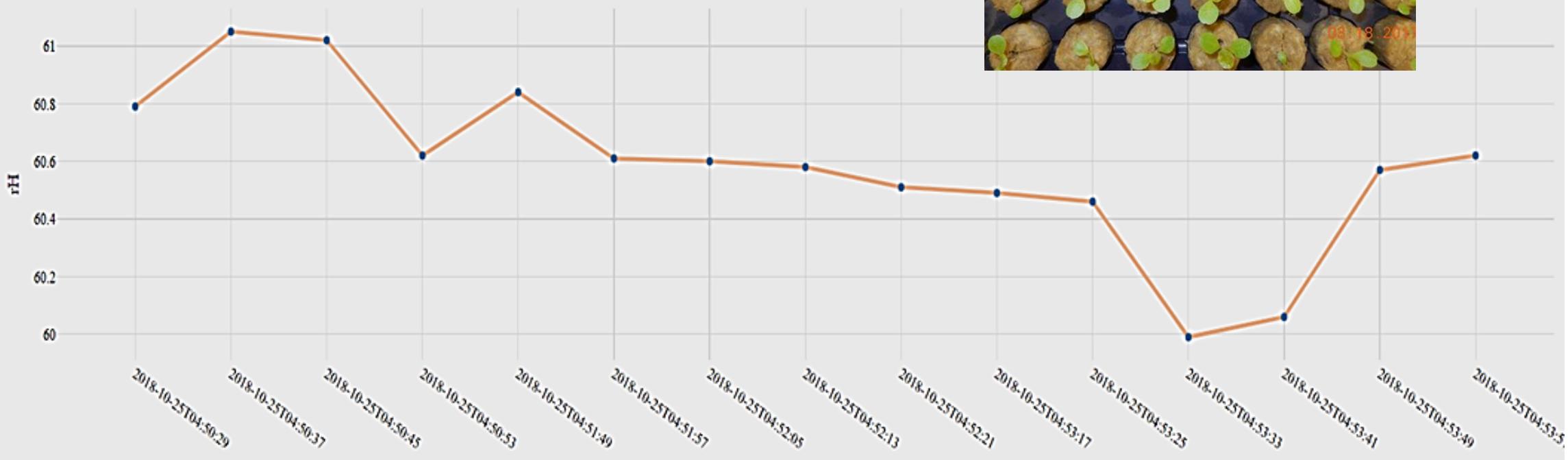
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SmartPath - HydroPatrol

Select System

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d0 CO2 EC temp3 temp2 temp1 M pH rH



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Emerick Larkin**

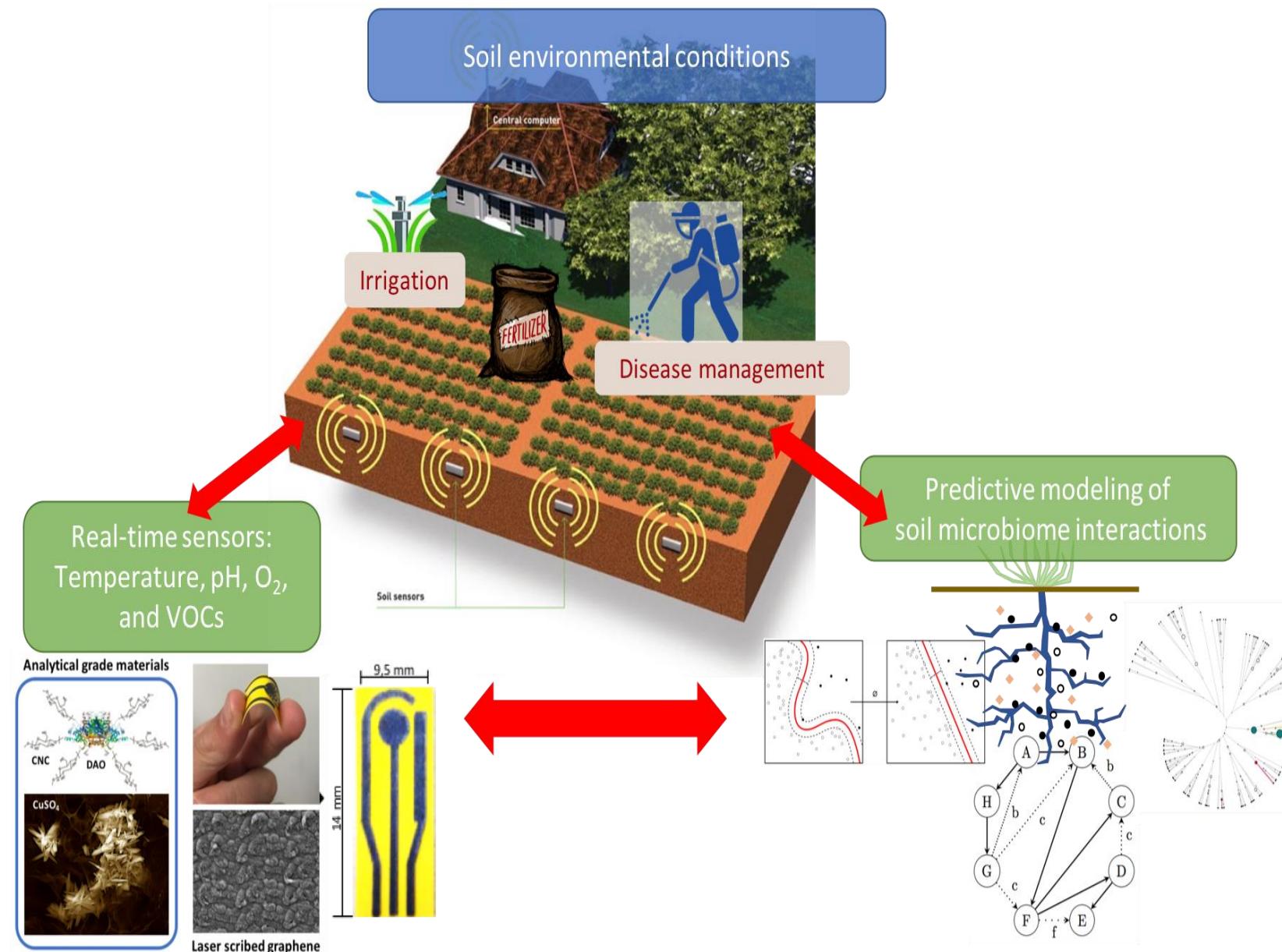
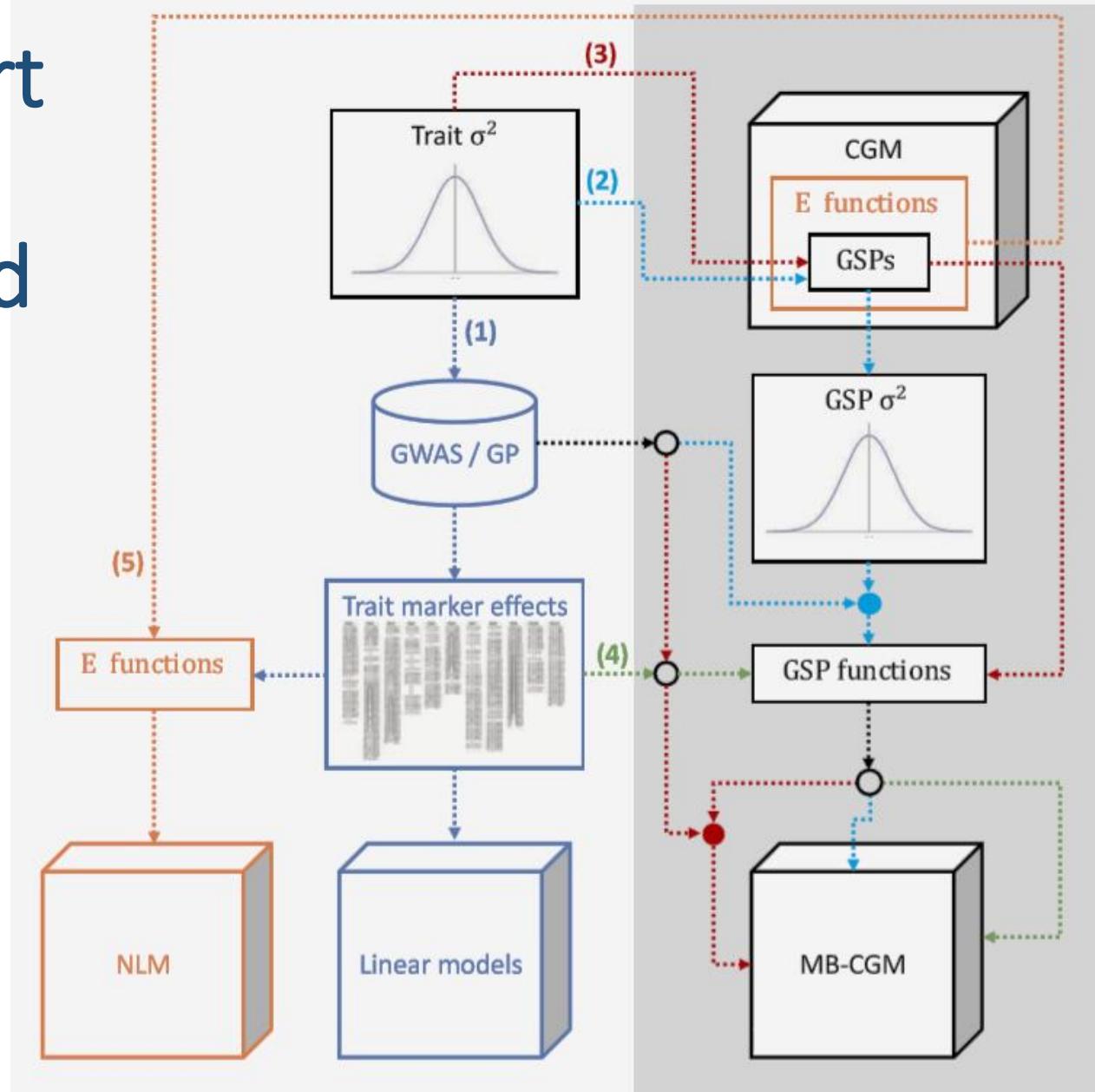


Figure 1 – Overview of autonomous soil sensor system, including long-lasting, ultra-low powered, sensor development, their validation in greenhouse experiments and in-field testbeds, and biophysical model development for healthy soil microbiome.

Improve Decision Support Tools → Crop Modeling Environment (abiotic and biotic)



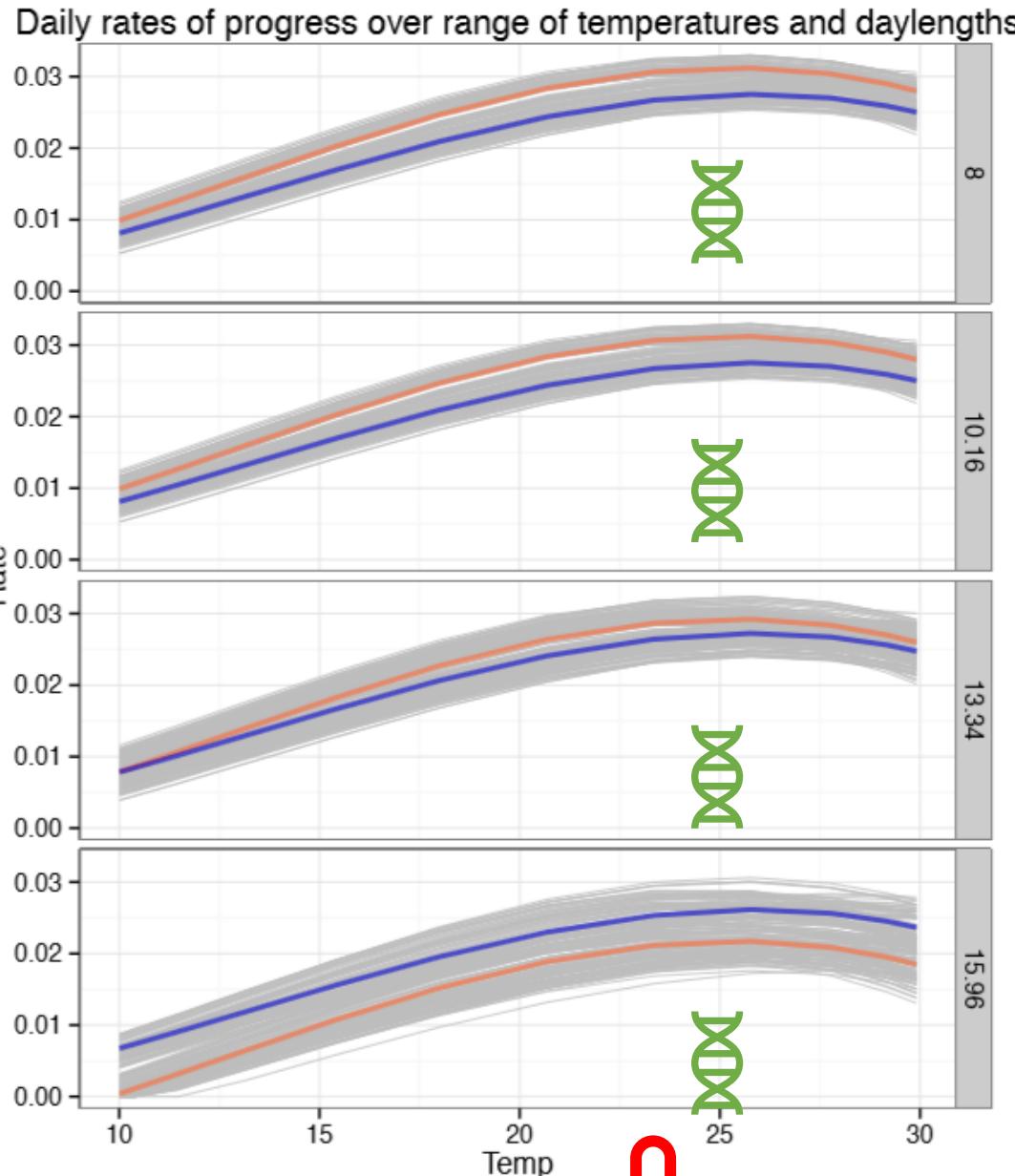
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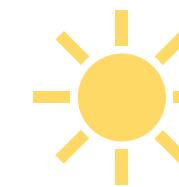
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Ph.D. student:
Christopher Hwang

Rate Towards Flowering (per hour)

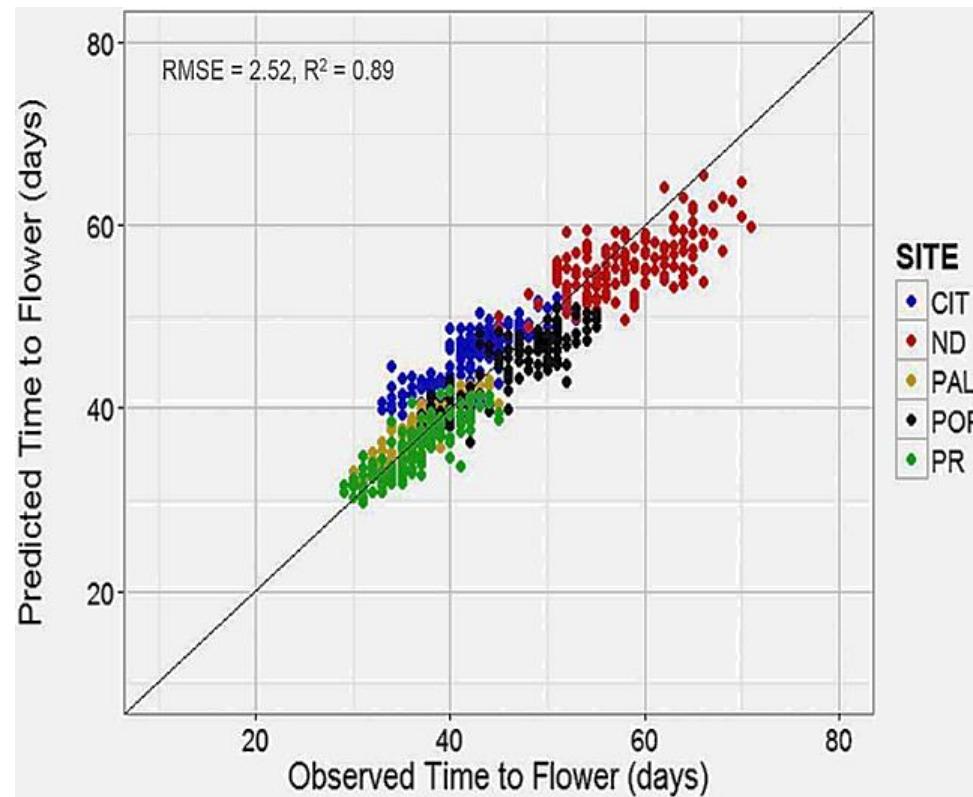


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Predicting Flowering Based on Genetic, Environment and G X E



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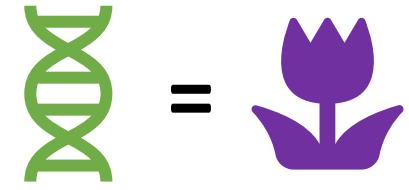
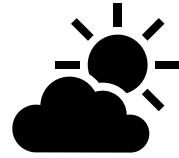
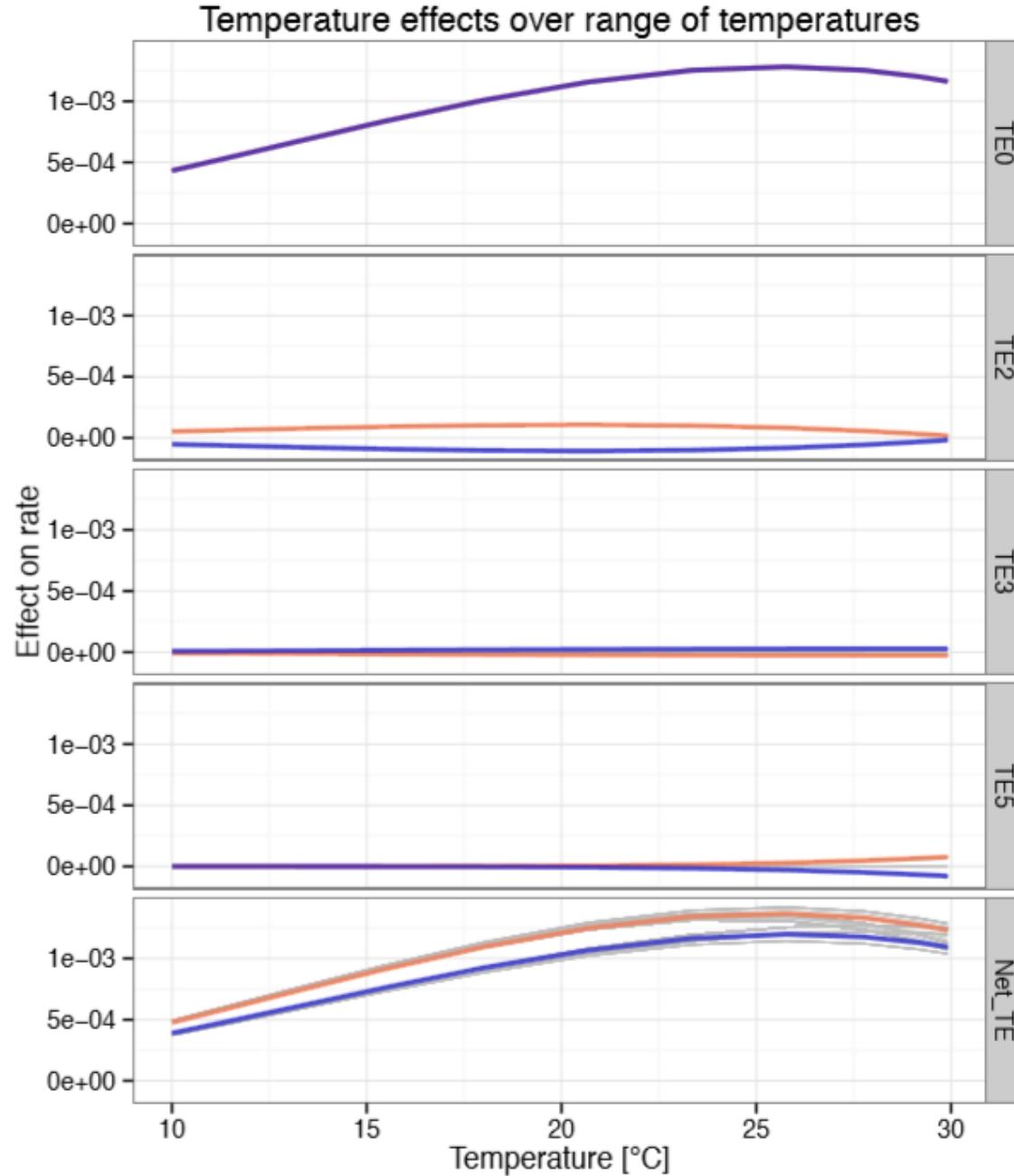
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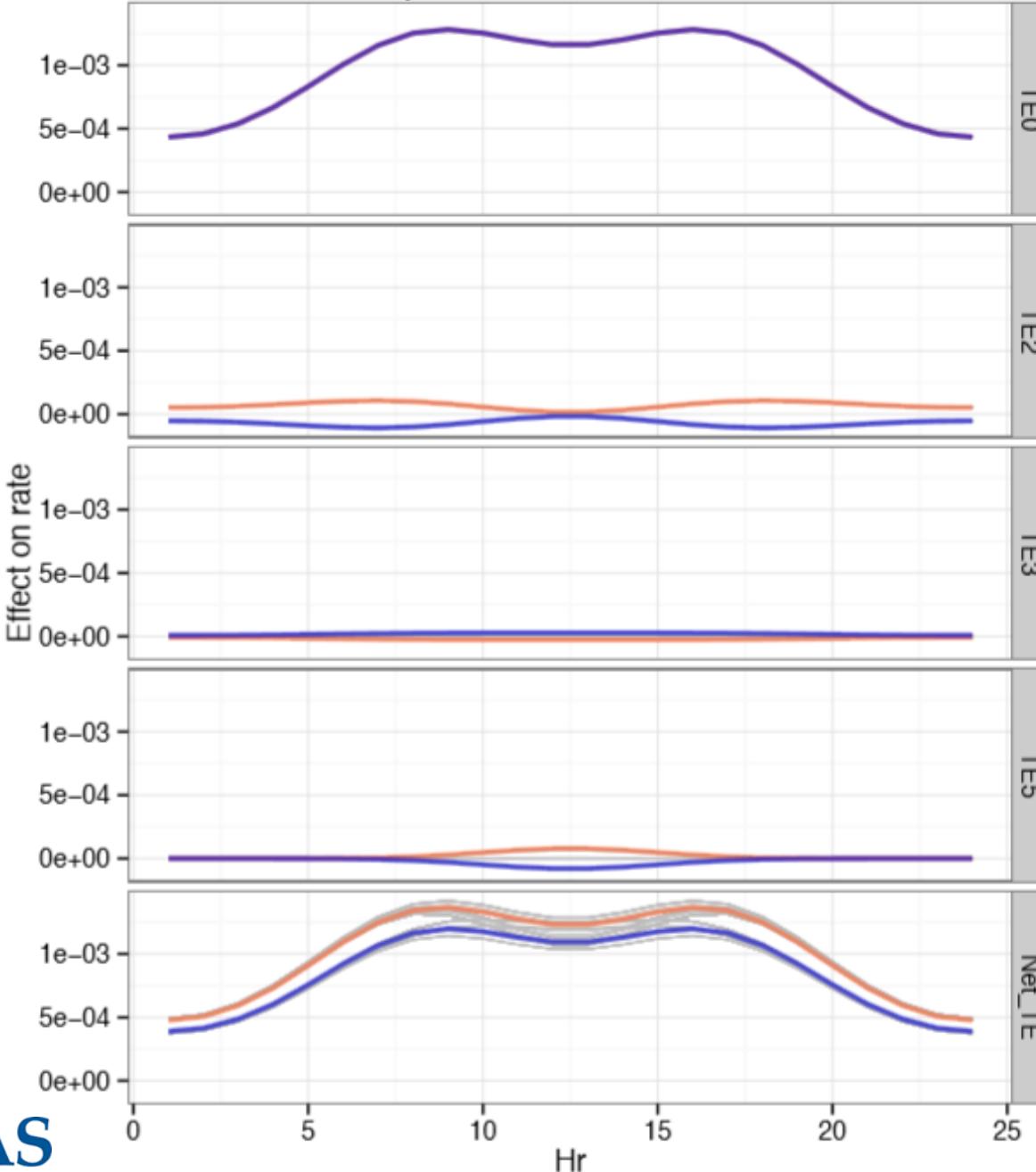
Rate Towards Flowering (per hour)



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Rate Towards Flowering (per hour)

Temperature effects over time

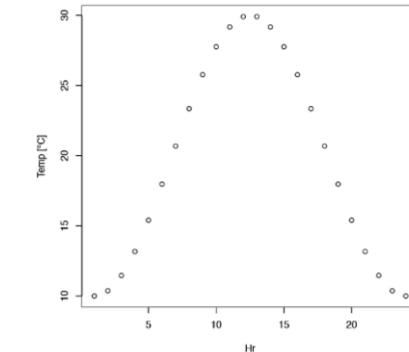


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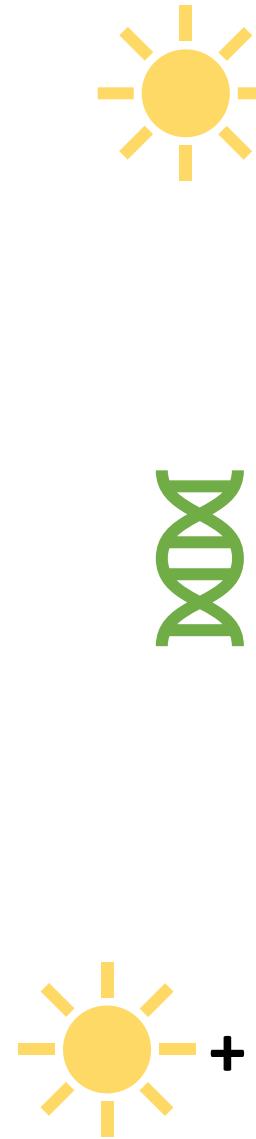
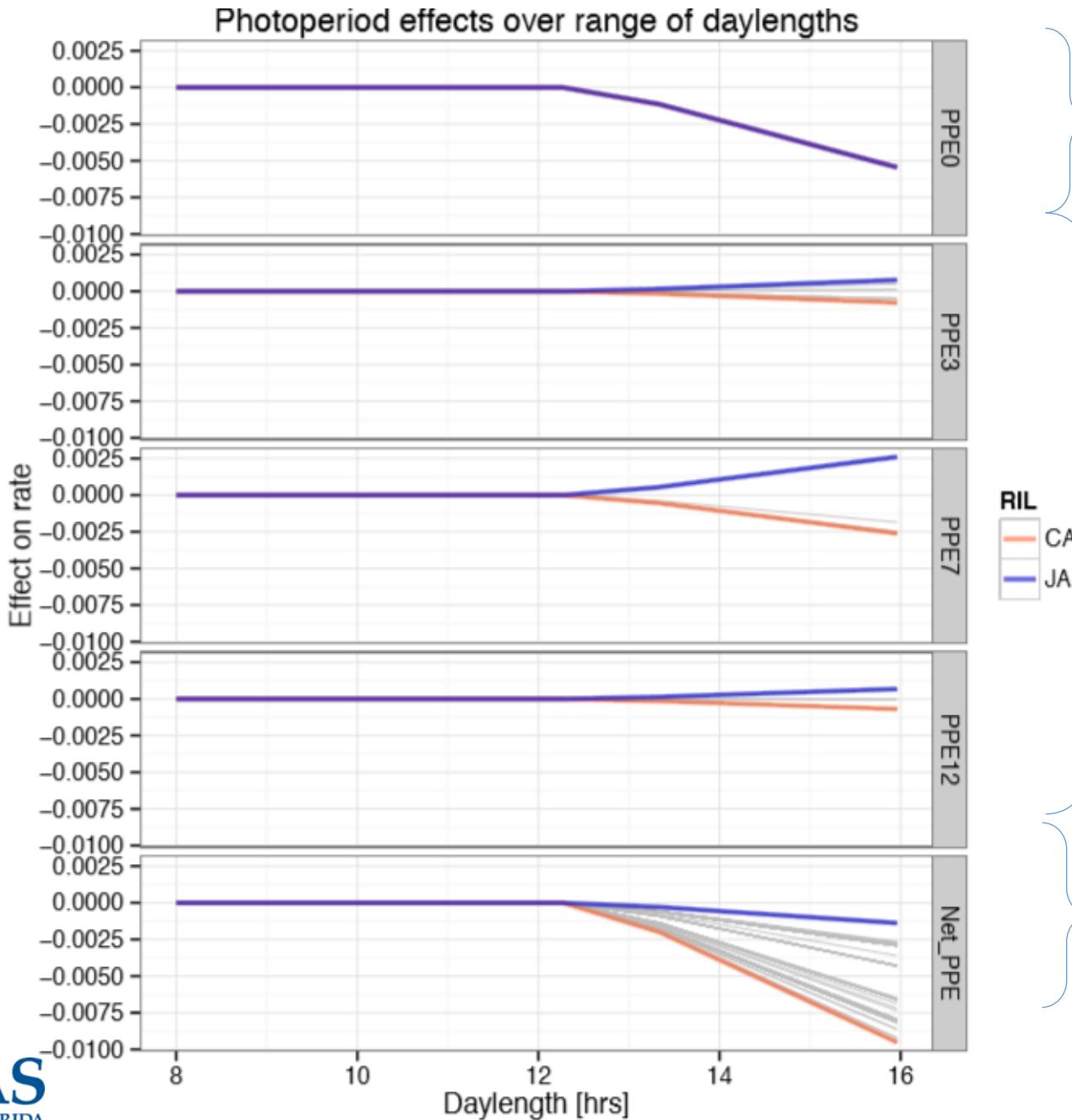
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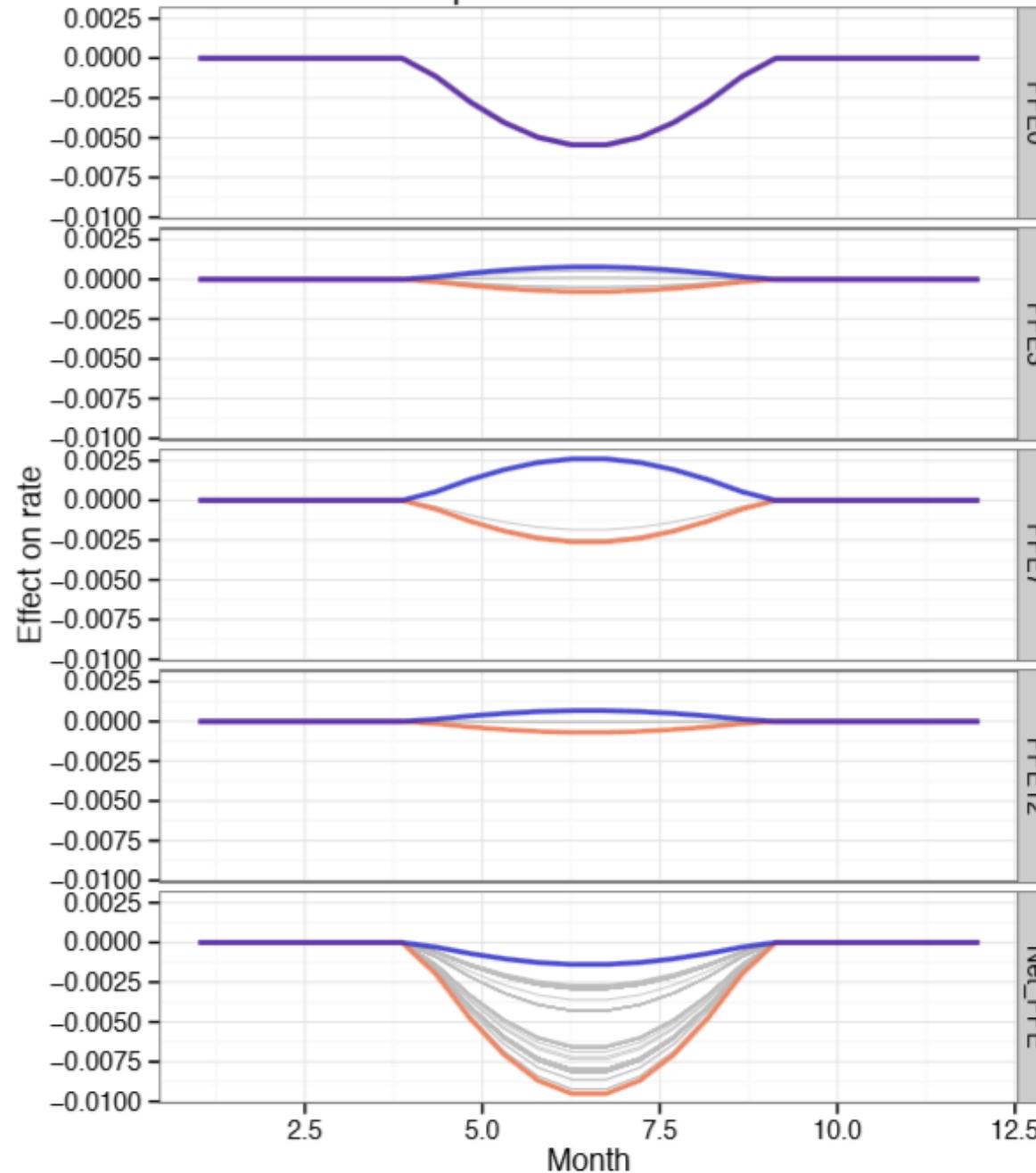
Rate Towards Flowering (per hour)



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Rate Towards Flowering (per hour)

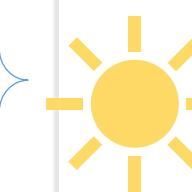
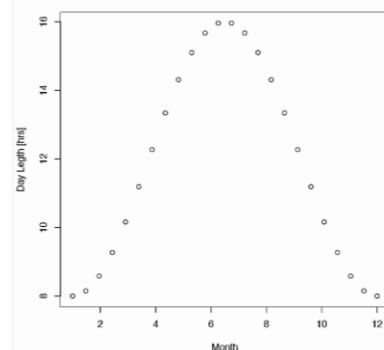
Photoperiod effects over time



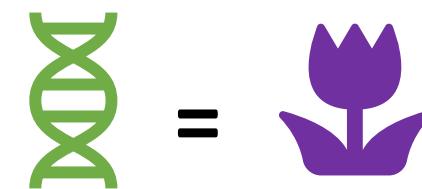
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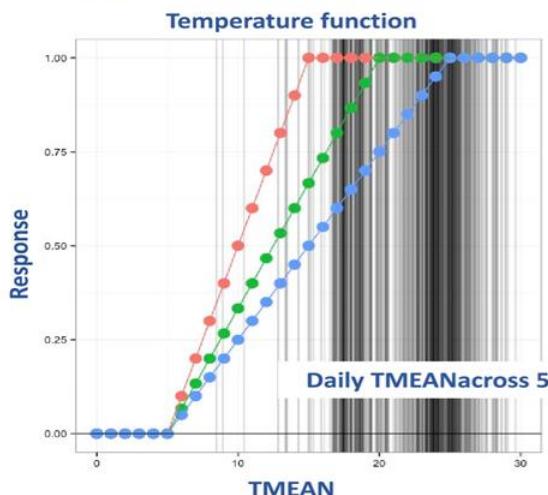
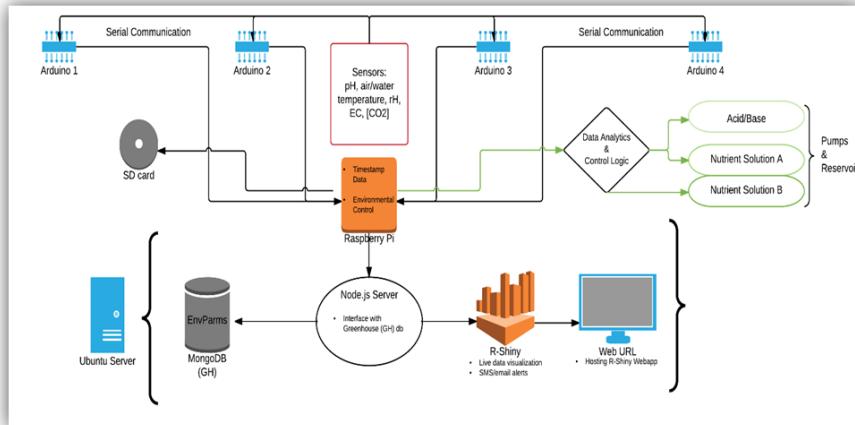


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Contributions to SmartAg, Farm of the Future



$$Ft_i = 44.18 + 4.026(\text{Day}_i - \text{Day}_m) + 0.1895(\text{Srad}_i - \text{Srad}_m) - 1.363(\text{Tmax}_i - \text{Tmax}_m) - 0.6091(\text{Tmin}_i - \text{Tmin}_m) - 1.31(\text{TF1}_i) - 2.279(\text{TF2}_i) + 1.59(\text{TF3}_i) - 0.5576(\text{TF4}_i) + 0.04971(\text{TF5}_i) - 0.8937(\text{TF6}_i) + 0.8774(\text{TF7}_i) + 0.3658(\text{TF8}_i) + 0.6629(\text{TF9}_i) + 0.3565(\text{TF10}_i) - 0.5583(\text{TF11}_i) + 0.326(\text{TF12}_i) - 0.3337(\text{TF1}_i * \text{TF2}_i) + 0.3031([\text{Tmin}_i - \text{Tmin}_m] * \text{TF2}_i) + 1.808([\text{Day}_i - \text{Day}_m] * \text{TF3}_i) + 0.1974([\text{Tmin}_i - \text{Tmin}_m] * \text{TF3}_i) - 0.1495([\text{Tmax}_i - \text{Tmax}_m] * \text{TF5}_i) + 0.4997([\text{Day}_i - \text{Day}_m] * \text{TF7}_i) + 0.0266([\text{Srad}_i - \text{Srad}_m] * \text{TF12}_i) - 0.2764([\text{Day}_i - \text{Day}_m] * \text{TF12}_i)$$

Topic: → Genotype to Phenotype based on Environment

- **Research (60%):** Developing tools to unravel the Genotype to Phenotype Grand Challenge
 - *Integrating Genetic Information into Crop Models (tools for plant breeders)*
 - *Biotic/Abiotic factors affecting plant growth and development (network analyses-microbiomes)*
 - *Using controlled environment agriculture (CEA agriculture) to understand the Genotype to Phenotype relationships*
- **Teaching (40%):** ABE 3000c (Applications in Biological Engineering): ABE 4662 (Quantification of Biological Processes); ABE 4905 (Industrial Hygiene); ABET Coordinator, *New Agroecology Course with Wageningen?*; iGEM faculty advisor (2017, reviewer 2018)
- **Current funding interest:** Crop Models, Genotype to Phenotype studies, hydroponics, digital ag, sensor technologies
- **Industry partners or interest in industry partners:** (SyNRGE, LLC via Dr. Gary Stutte, Florida Space Grant Partner), CEA companies, Monsanto/Climate Corp.

