

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

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

CBS NEWS / June 22, 2017, 8:24 AM
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 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.”

Science for Environment Policy
Climate change threatens early-flowering plants due to lack of snow

Among the ecological effects of climate change are changes to the timing of natural events, such as flowering. To understand why these phenological changes affect reproduction, this study manipulated conditions in a spring herb to prompt premature flowering. This exposed the flowers to frost, and resulting damage caused dramatic reductions in plant reproduction, suggesting that climate change may threaten plant survival.

Known as nature's calendar, phenology describes the timing of critical events, such as when flowers bloom, birds migrate or trees shed their leaves. These processes are closely linked to environmental conditions, such as temperature.

As the climate warms, therefore, the timing of life history events of plants and animals are changing, which may have implications for reproduction. In particular, changes to when plants flower can have dramatic effects on their survival and seed production and, therefore, fitness, with implications for survival of the population and perhaps even the species. It is important to investigate this process in order to understand how plant species across the world will respond to a changing climate.

Changes to phenology can affect reproduction in various ways. First, changes to the timing of flowering influence the conditions the plant will experience. For example, early flowering may increase the risk of frost damage in some plant species, which has a knock-on effect on seed production. Changes in phenology can also lead to 'mismatches' between plants and seed production. Changes in phenology can also lead to 'mismatches' between plants and seed production. Changes in phenology can also lead to 'mismatches' between plants and seed production.

This study investigated both possibilities. The researchers experimentally altered the timing of flowering and observed the effects on plant-pollinator interactions and reproductive success. As a case study, they used the wildflower *Claytonia lanceolata*, which is found in Canada and the US. It thrives in the rocky soil of alpine climates and flowers early in the spring. The timing of its flowering is closely linked to when the snow melts.

The researchers manipulated flowering in two ways. Both experiments were conducted in the subalpine meadows in Colorado, USA. First, they removed snow from the area where the plants grow to induce earlier flowering (flowering 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.

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

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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. The state’s strawberry season has been test cases for global warming.
November, the hotter-than-normal weather pushed the first crop of young plants, pushing the first crop

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ADIRONDACK ALMANACK
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SATURDAY, MARCH 11, 2017
Arrival of Spring, Phenology and Climate Change
by Richard Galt

How do you know when spring has begun? Is it the first snow? The first crocuses coming up through the frozen blackbirds? The clamor of peepers? Apple trees and lilacs blooming?

Adirondack Explorer defines phenology, which is derived from the Greek word 'phaino' meaning to show or appear, as 'a branch of science dealing with the relations between climate and periodic biological phenomena.' Think of it as a timeline or chronology of periodic natural events, such as when insects hatch or arrive, when flowers and plants emerge, bloom, and produce seed, when migrating birds and insects (e.g. monarch 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 with over the years use phenological correlations to determine planting times, often favoring plants. Examples I've heard include planting peas when forsythia blooms; potatoes when the first dandelions bloom; beans, carrots, crucifers (e.g. cabbage, cauliflower, broccoli) when black locusts are in first leaf; beans, cucumbers, and squash when lilacs are in full bloom; tomatoes

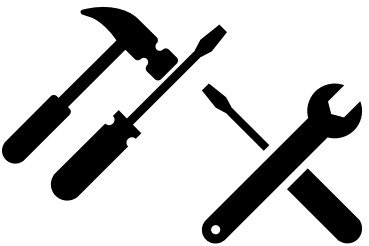
2 Comments
of maple sap? The first crocuses coming up through the frozen blackbirds? The clamor of peepers? Apple trees and lilacs blooming?

Latest Adirondack News
DOT Debating Salt Reduction Program
Ti Country Club Intends to Rebuild
WCS Ending Adirondack Program
Report: Benne Considering 2020 Run
2 Outed From LG School Board
Appeal Notice Filed Over ATV Order
Kayaker Injured in Moose River
Report: Rutgers Preferred Trump
Placid Community To 'Climate Smart' Program
Five Levels Ti Restaurant, Country Club

Current Conditions
Events
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Sign the petition to PROTECT ADIRONDACK WILDERNESS FROM OVERUSE
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Recent Almanack



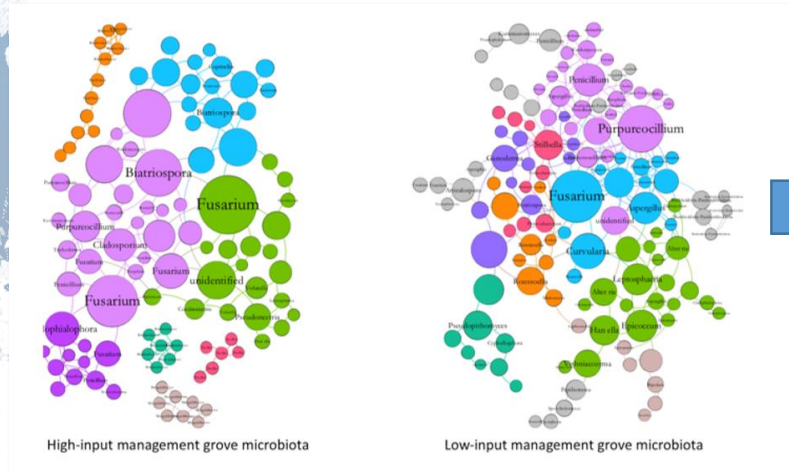
Plant Breeders and Farmers Need Decision Support Tools



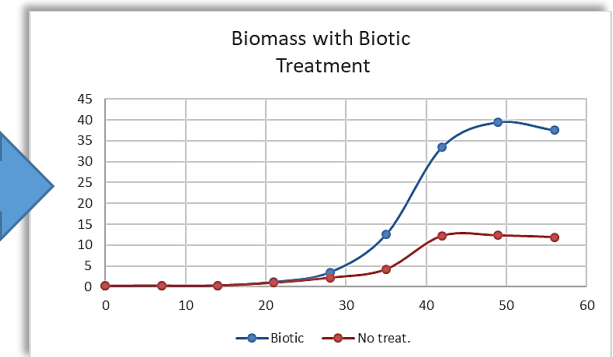
- It takes approximately 10 years for a new genotype of a crop to make it to market.
- As climates change, new crop cultivars (genotypes) need to be created that are adapted to these changes (i.e., the targeted environments).
- Plant breeders need computational tools to design and test new genotypes 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



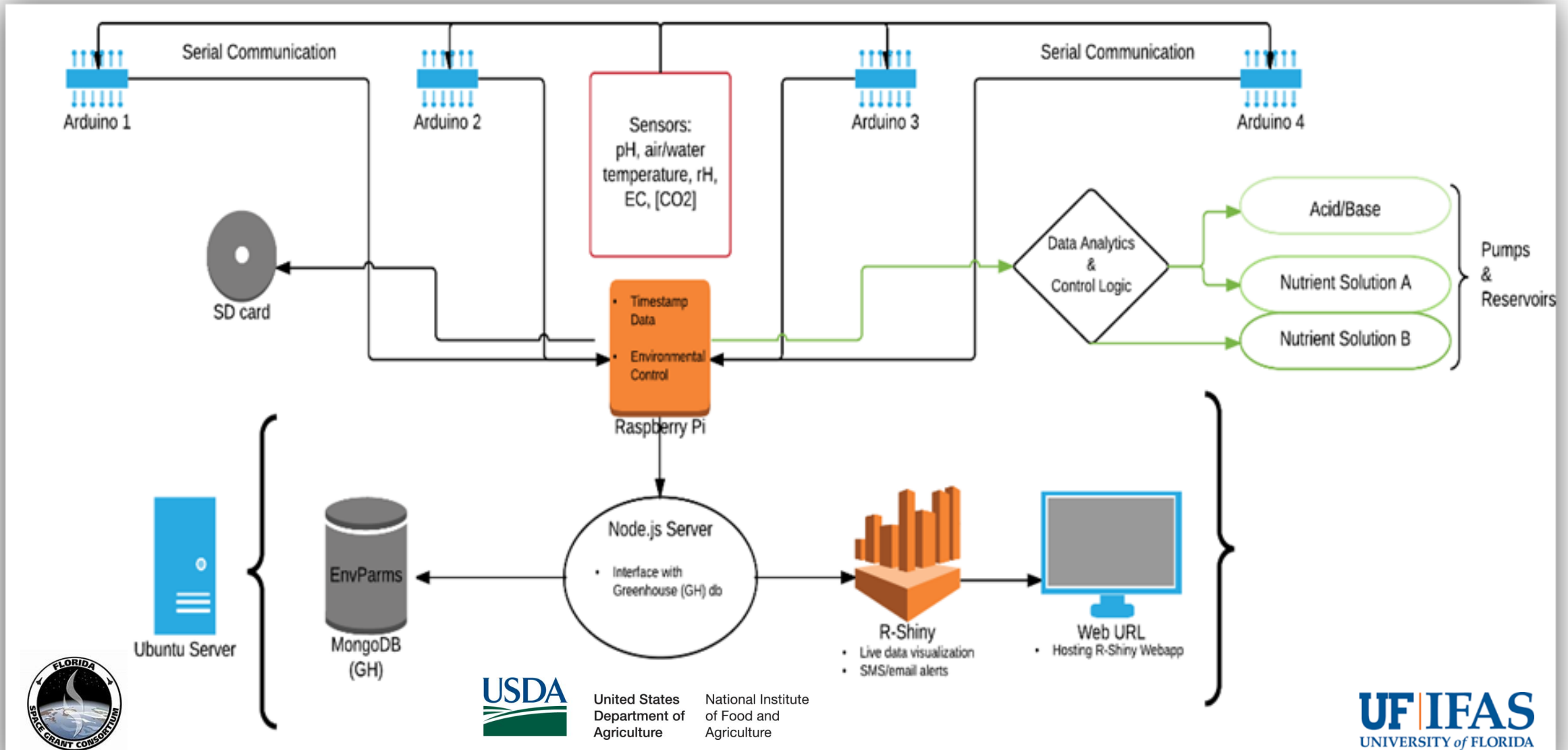
Predictive Model of Plant Growth



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

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

Ph.D. student:
Emerick Larkin

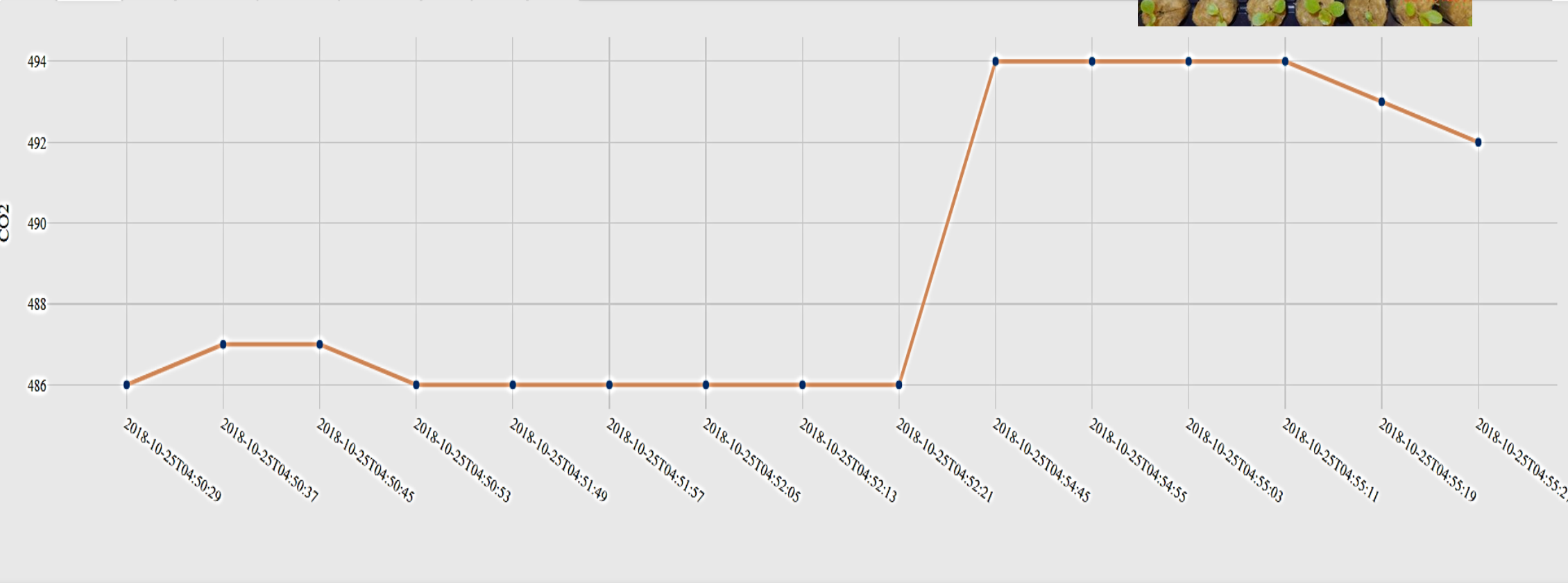


SmartPath - HydroPatrol

Select System

B4E62D2726AF ▼

dO	CO2	EC	temp3	temp2	temp1	lvl	pH	rH
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Resolution:

10



Minutes Back:

60

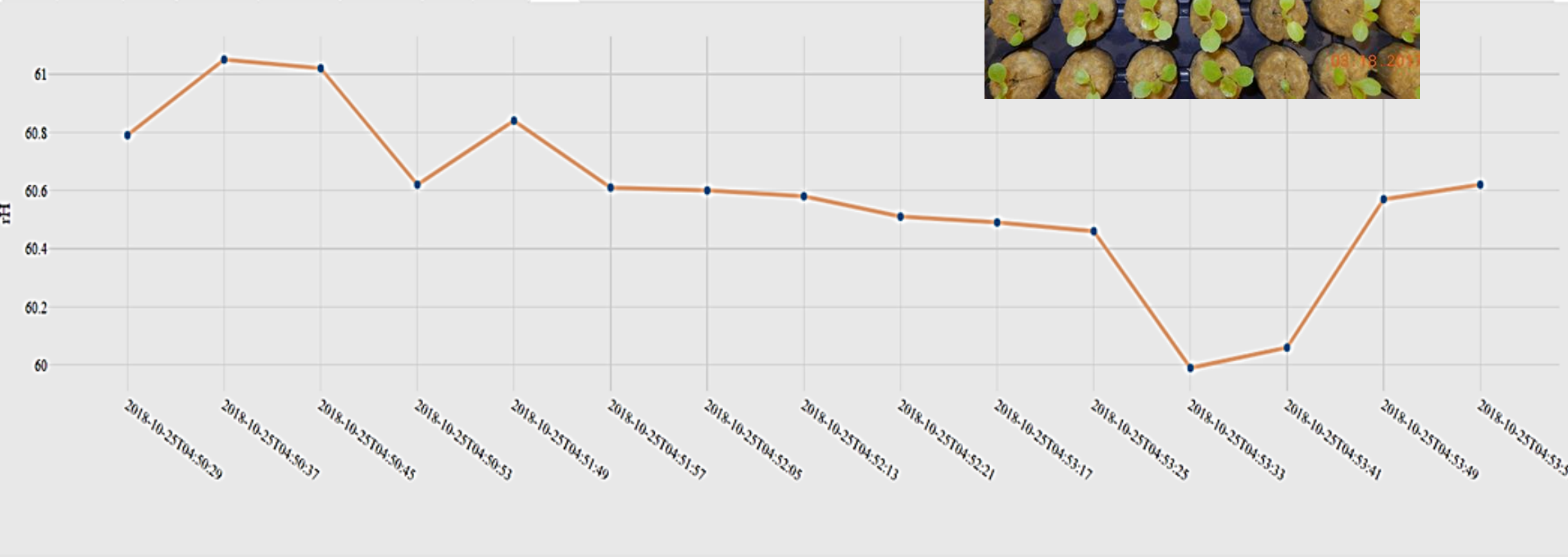
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Select System

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dO CO2 EC temp3 temp2 temp1 lml pH rH



Resolution:

10



Minutes Back:

60

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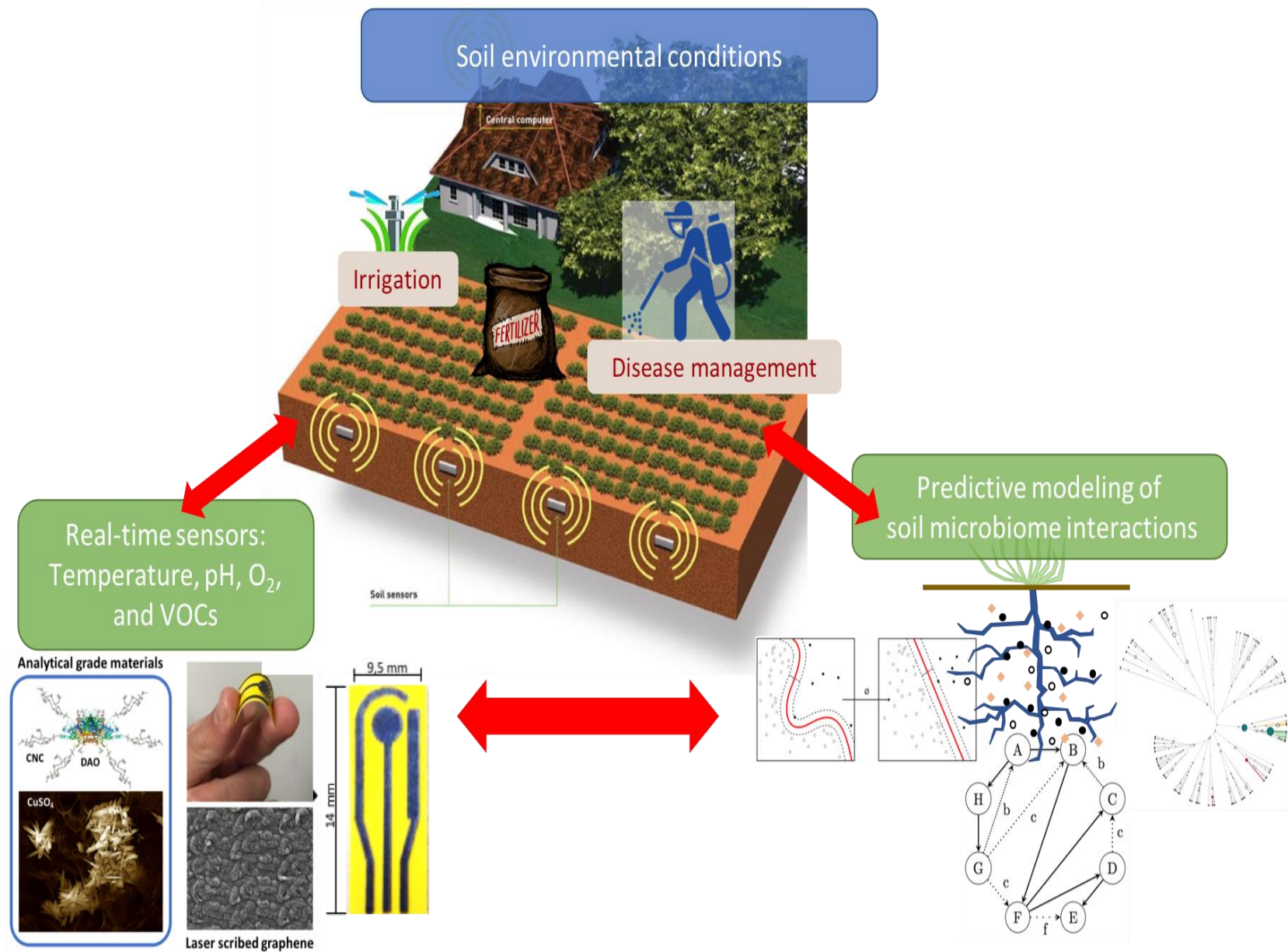
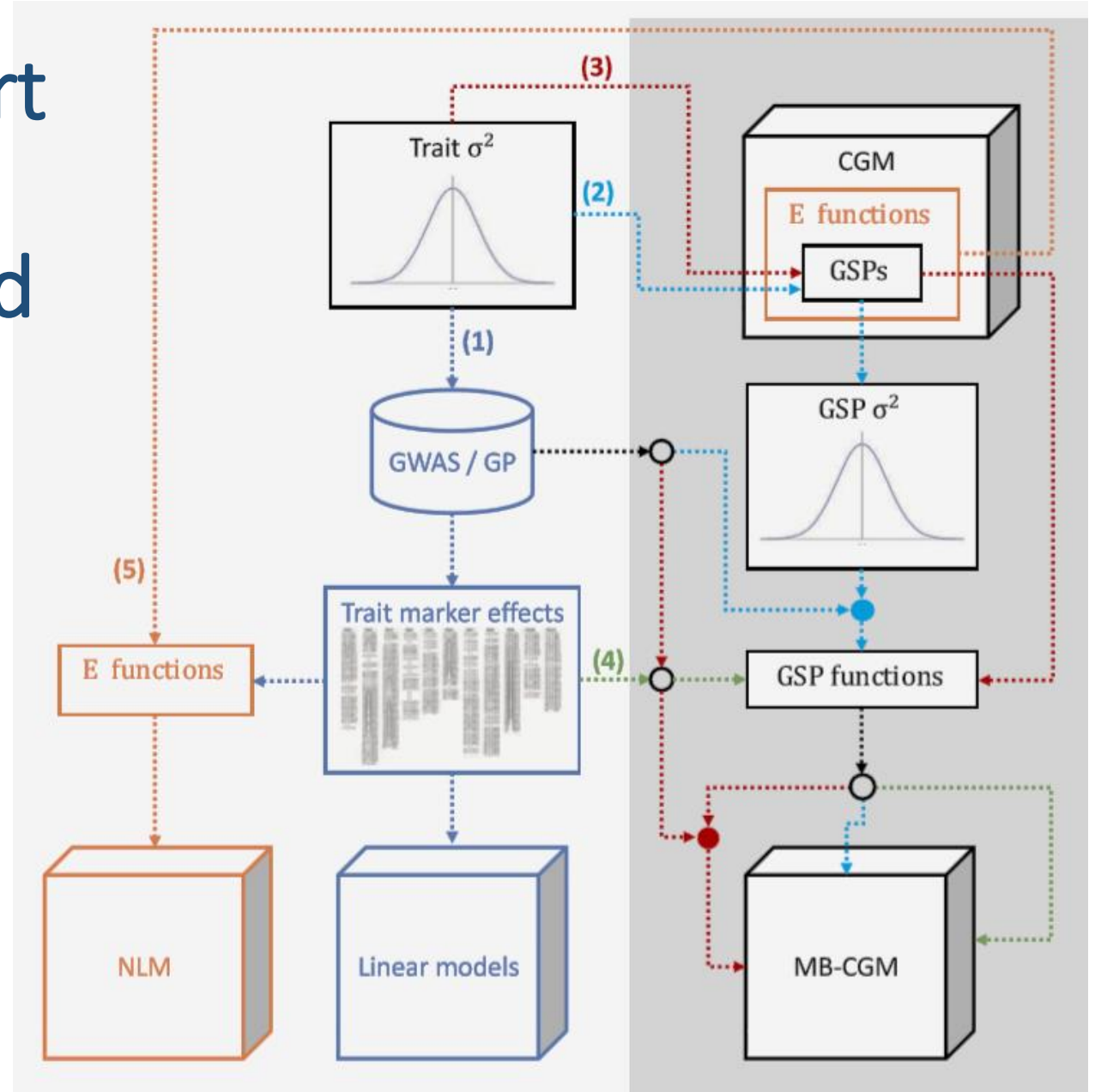


Figure 1 – Overview of autonomous soil sensor system, including long-lasting, ultra-low powered, sensor development, their validation in greenhouse experiments and in-field testbeds, and biophysical model development for healthy soil microbiome.

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



Ph.D. student:
Christopher Hwang

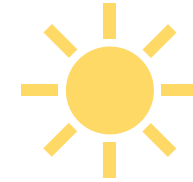
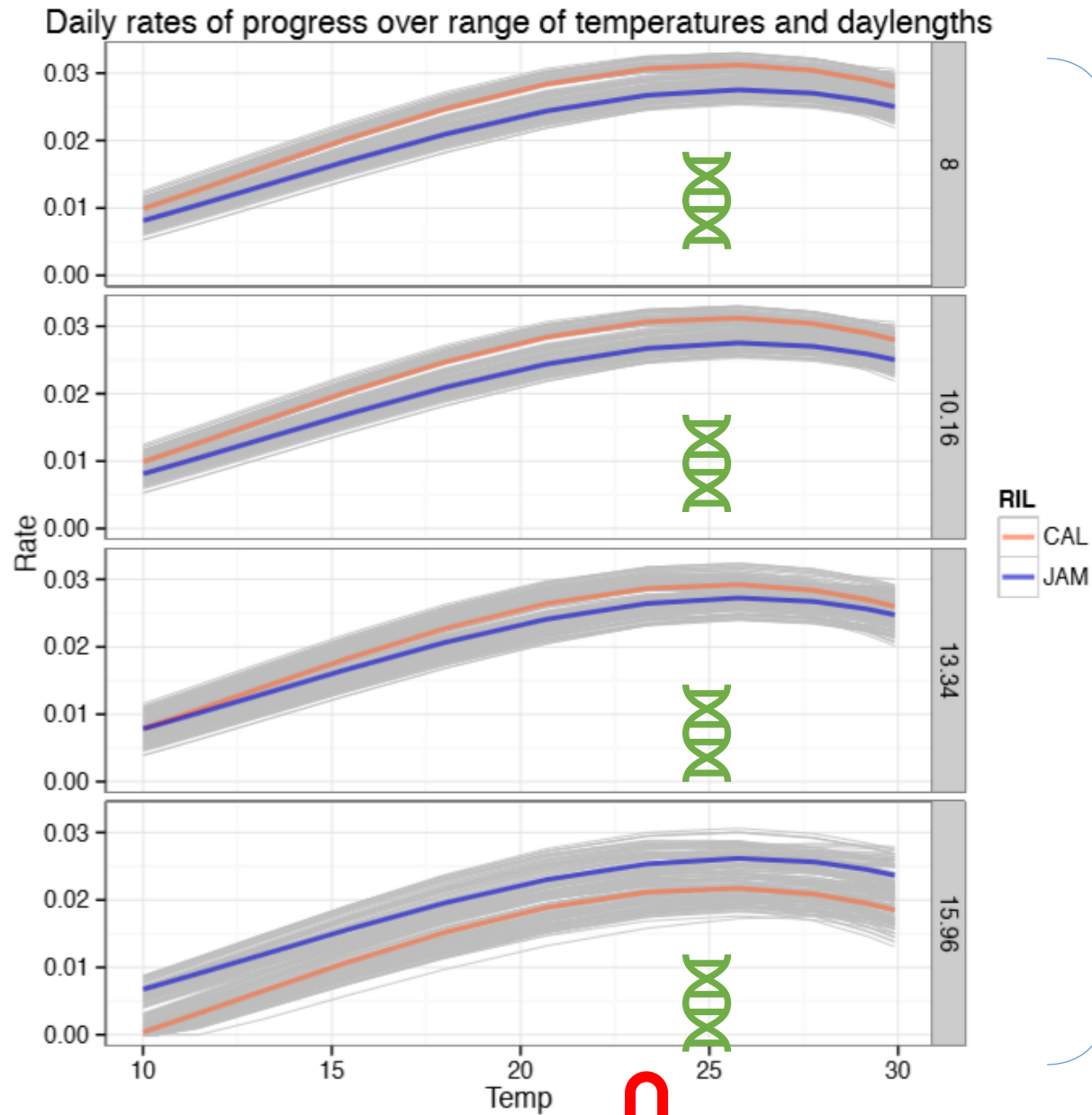


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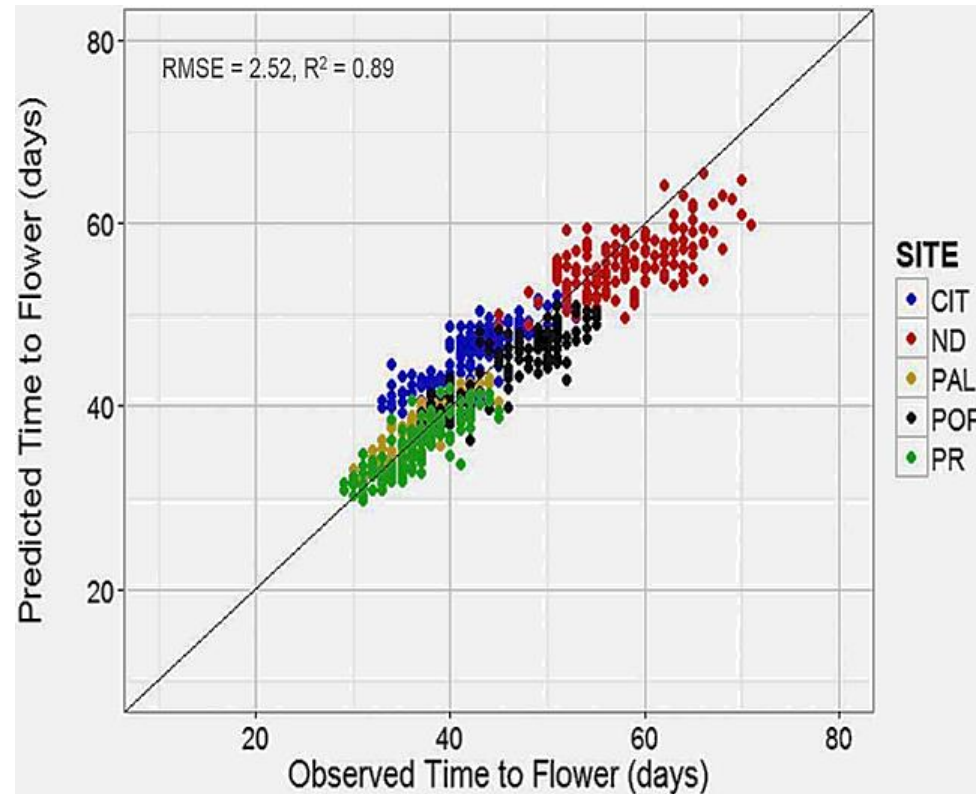


Rate Towards Flowering (per hour)



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Christopher Hwang

Predicting Flowering Based on Genetic, Environment and G X E



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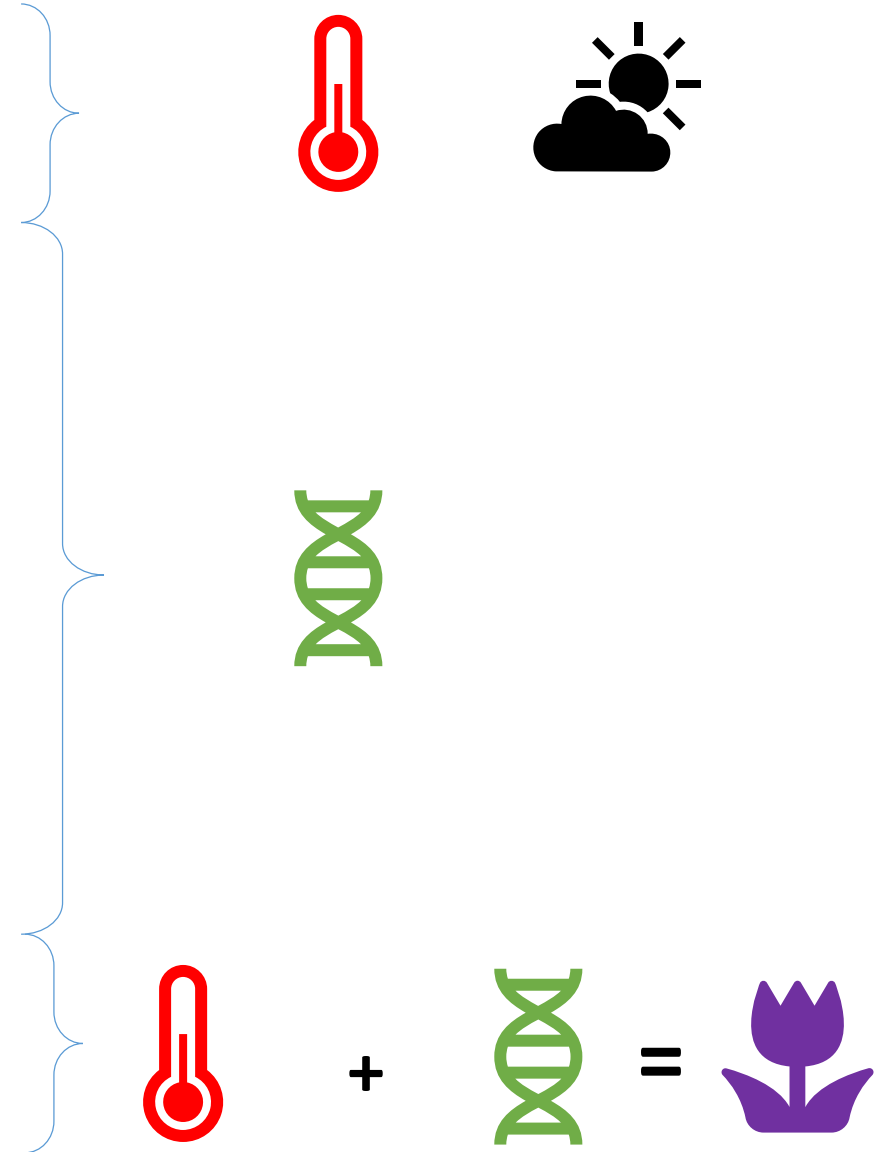
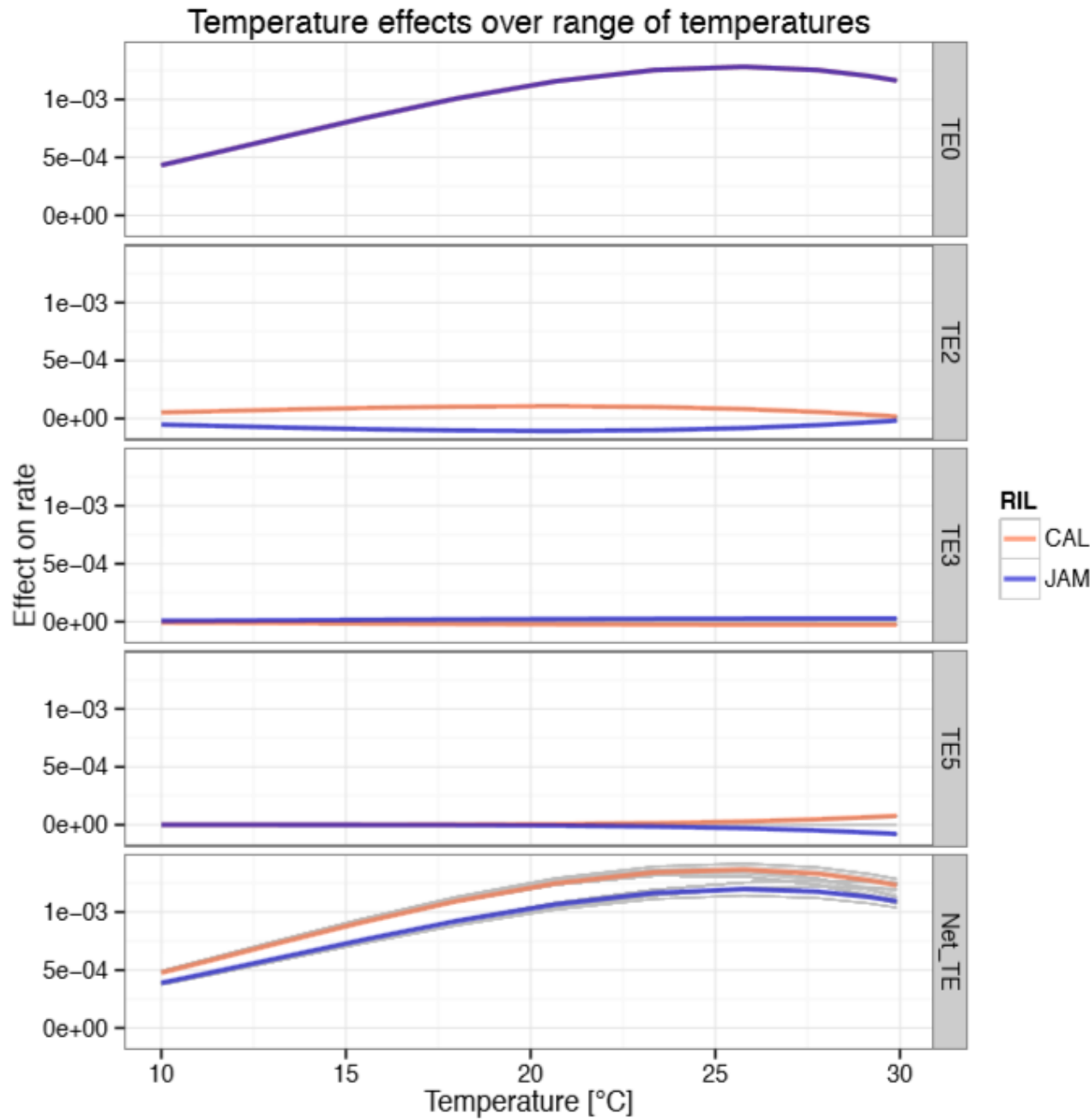


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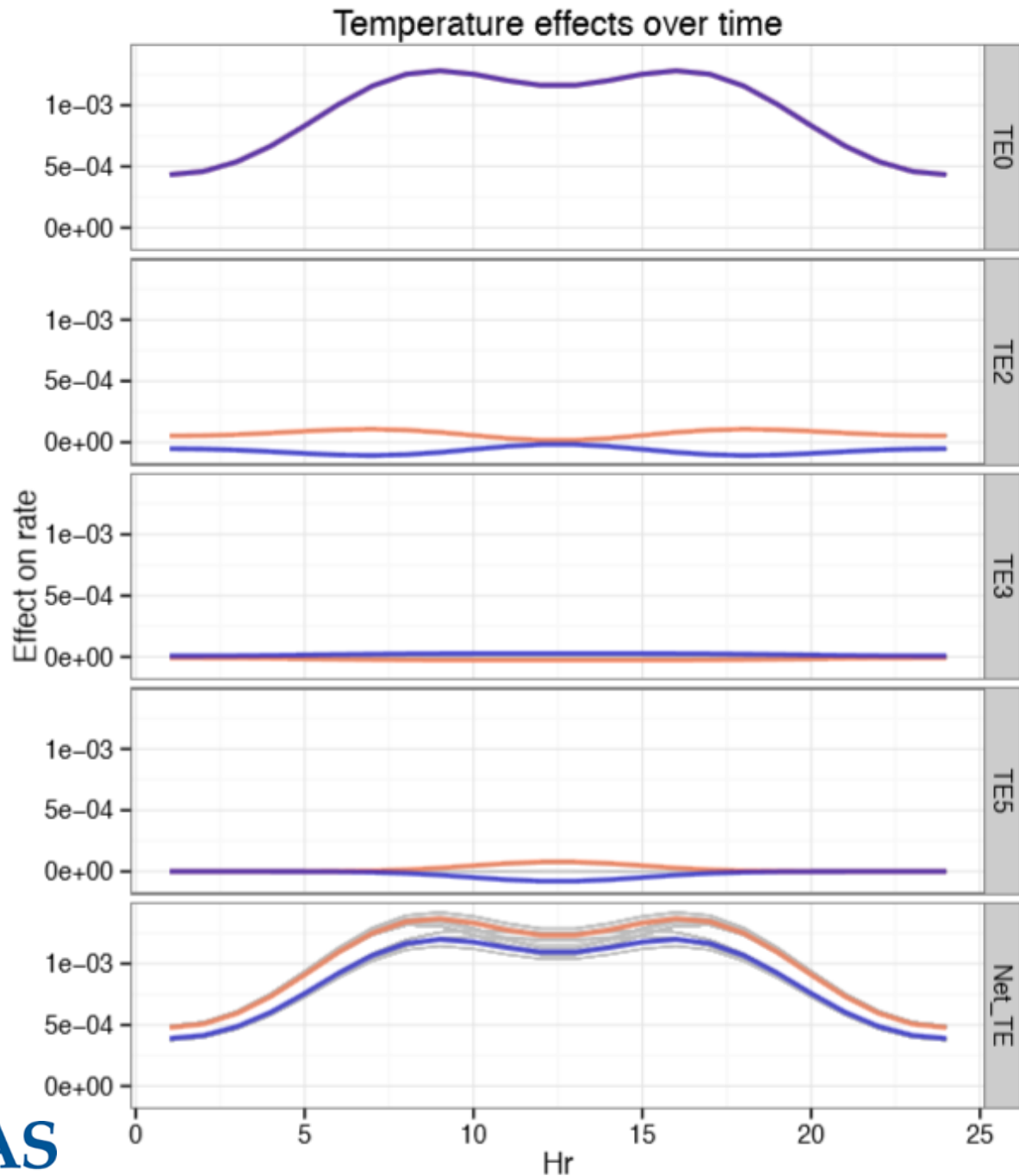


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Rate Towards Flowering (per hour)



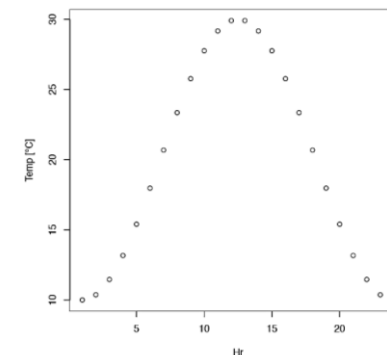
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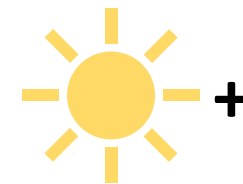
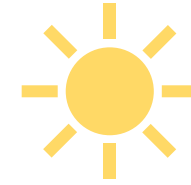
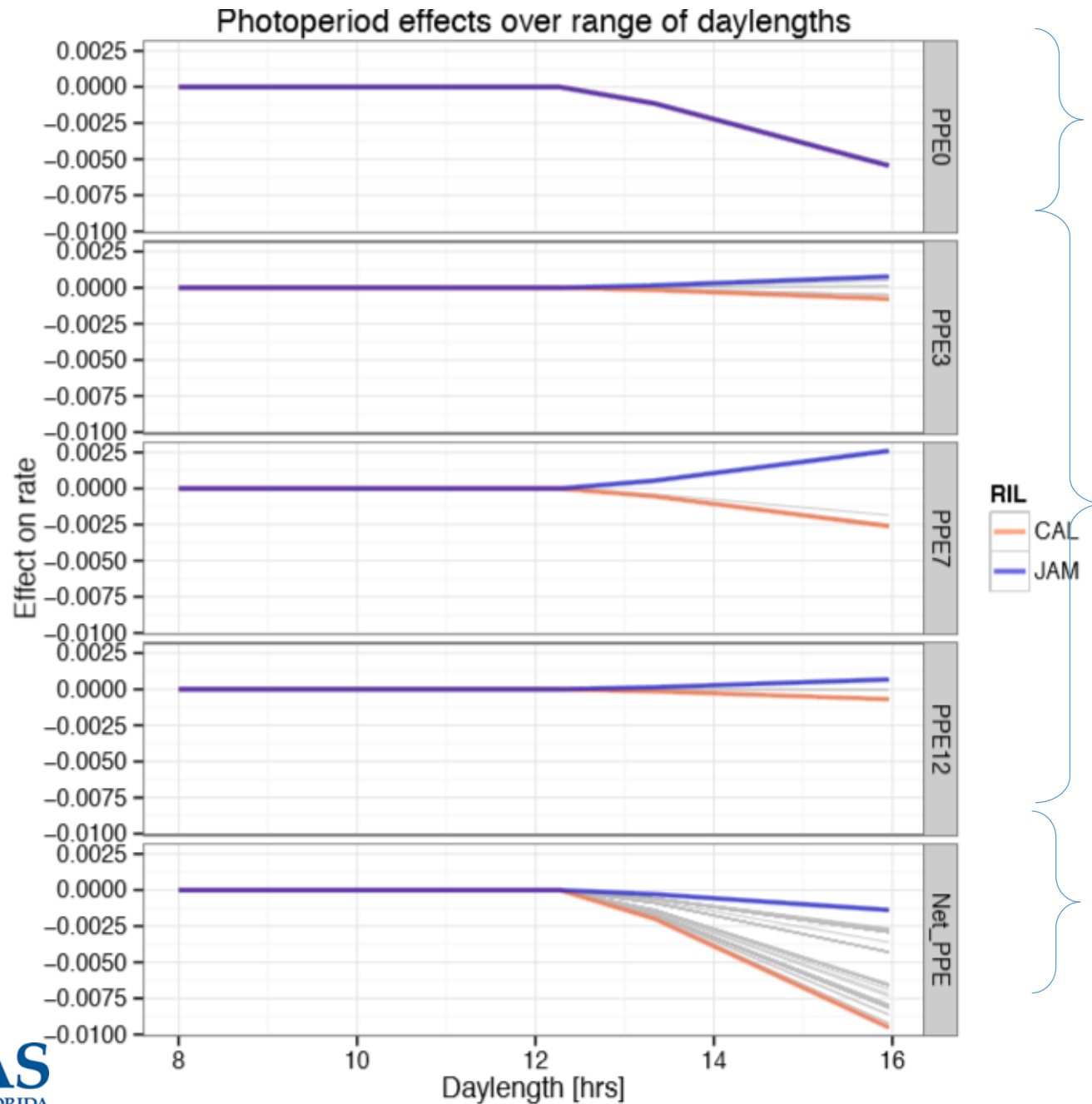


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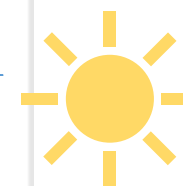
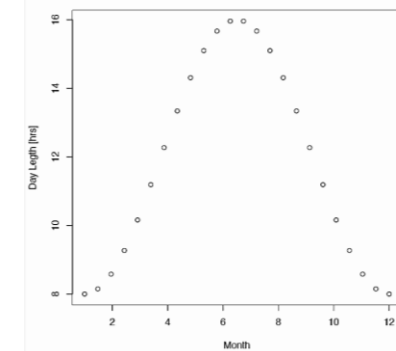
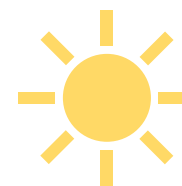
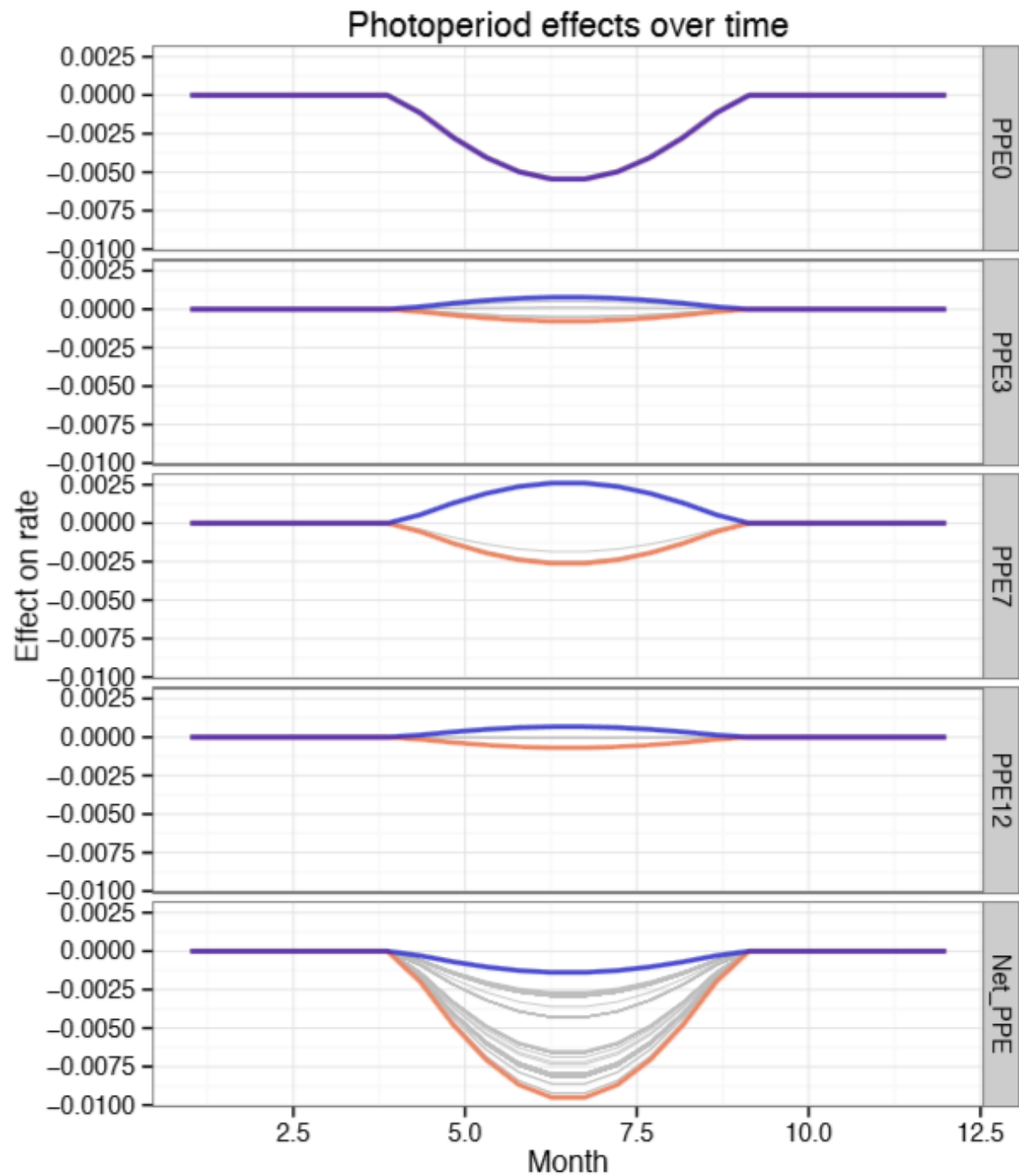


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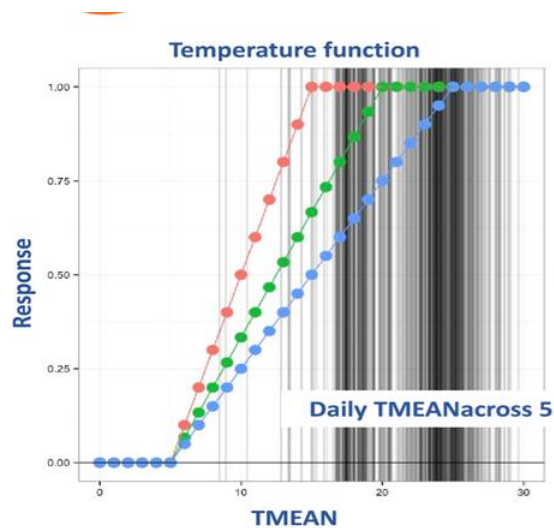
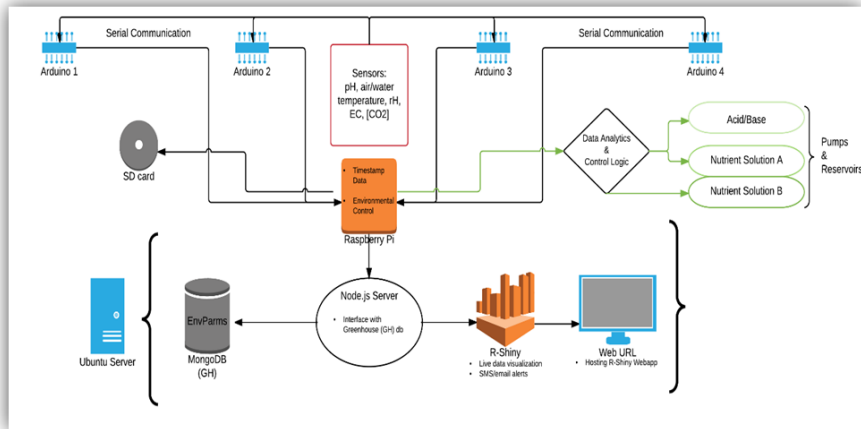


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Contributions to SmartAg, Farm of the Future



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

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.

