Strawberry Plant Wetness Detection using Color Imaging & Artificial Intelligence for the Strawberry Advisory System (SAS)

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Acknowledgement

- Florida Strawberry Research & Education Foundation (FSREF)
- Florida Foundation Seed Producers (FFSP)

Strawberry Advisory System (SAS)

WEATHER STATION INFO

Bronson

FAWN

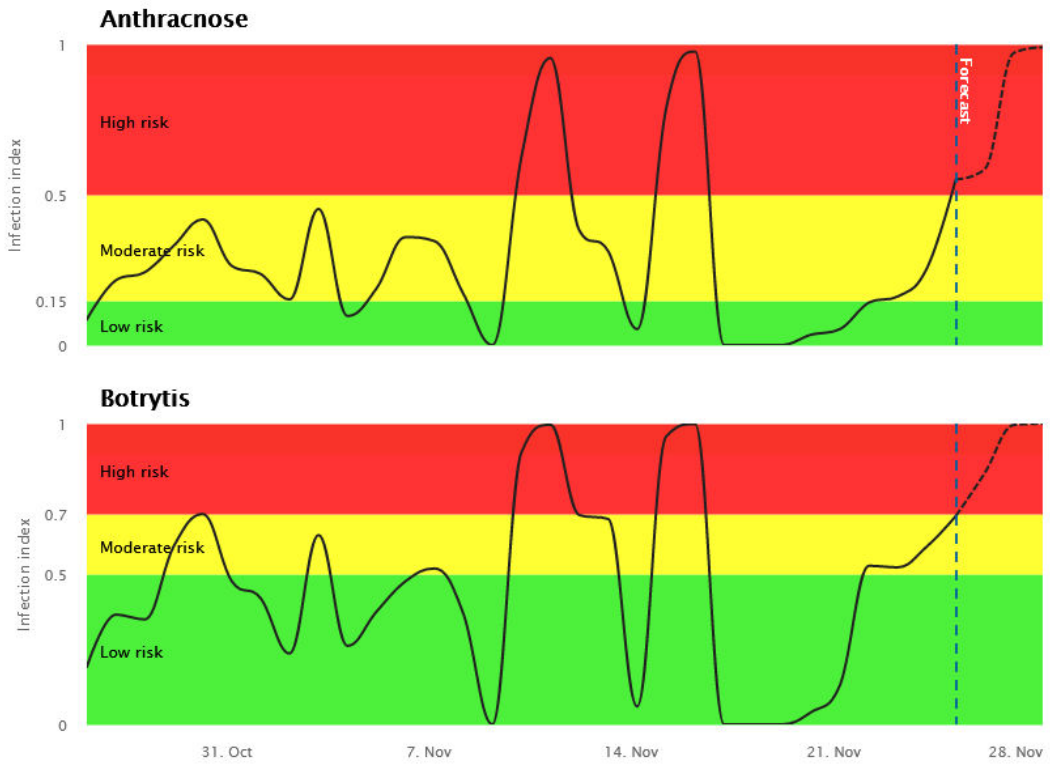
29.400, -82.586
Bronson, FL
Levy county

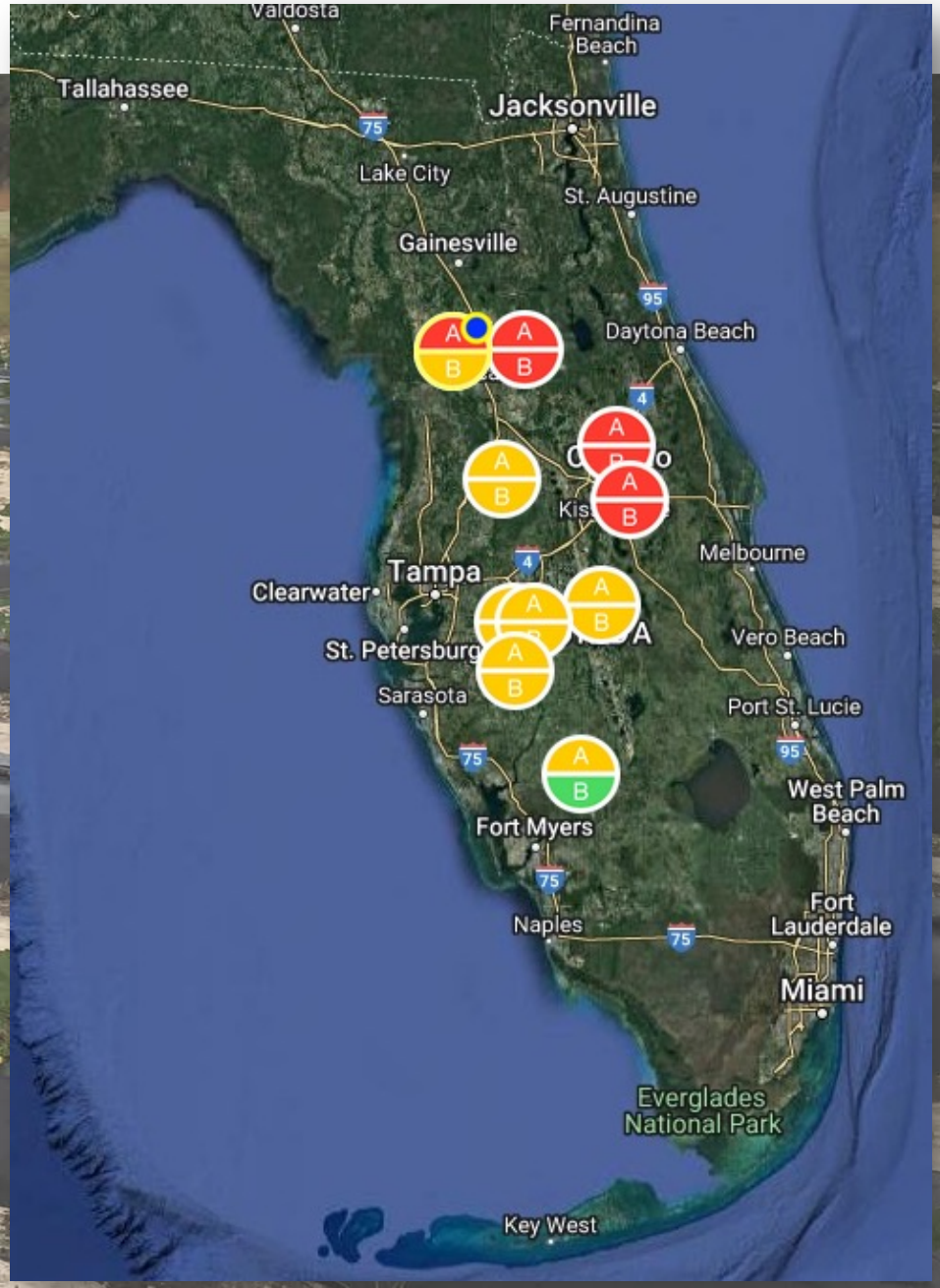
Highest risk recorded today
Simulated at: 11/25/2022 14:45

Anthracnose
Level: High

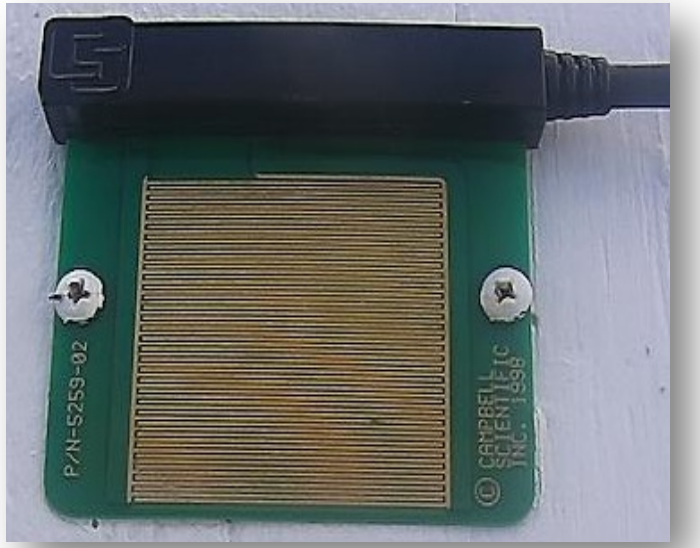
Botrytis
Level: Moderate

Disease Chart





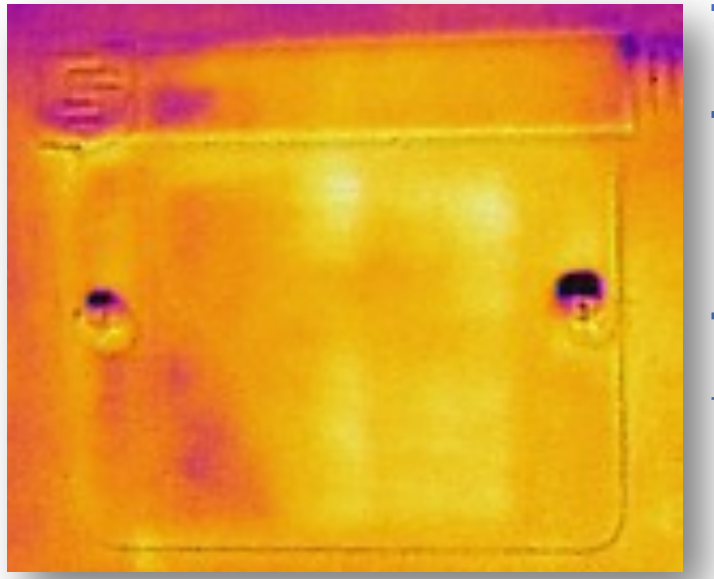
Background

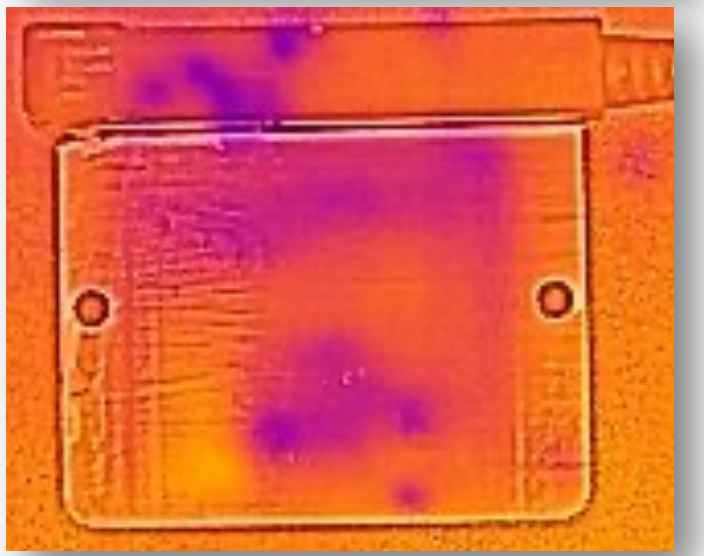


Campbell Scientific L-237
leaf wetness sensor

Sensor painted with white latex paint

Color images



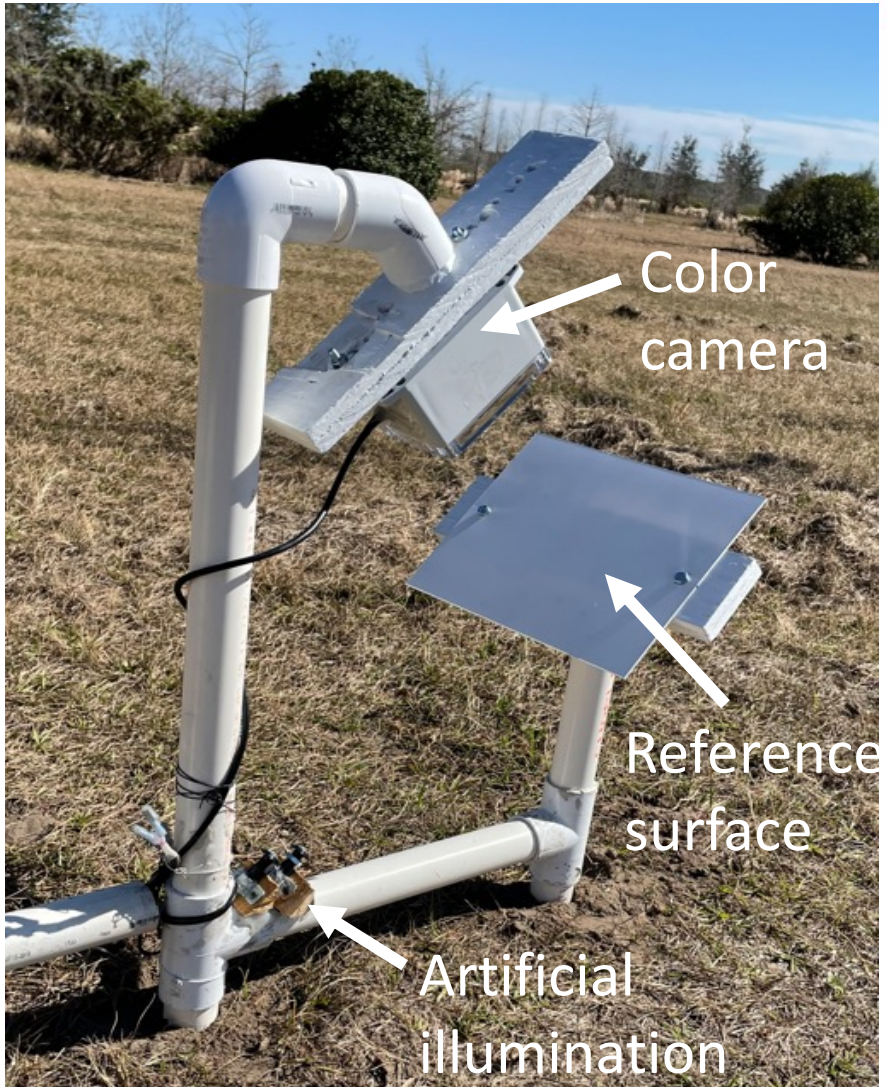


Thermal images

2021-22 Accomplishments

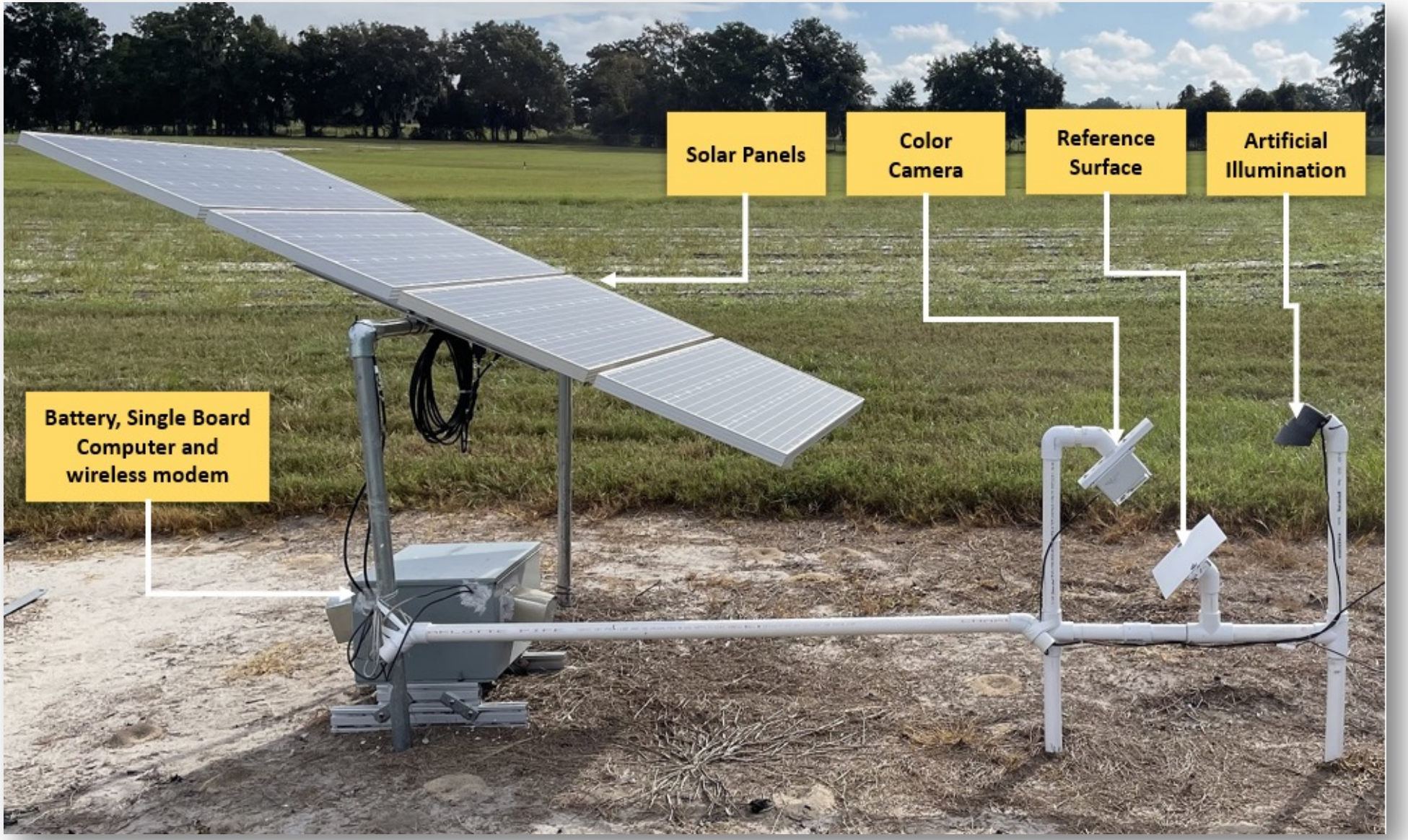
System Setup

- A 24 x 20 cm **white polypropylene sheet** was used as a reference surface.
- The reference surface was placed 45 cm above ground level, facing north, at an angle of 45° from the ground.
- A 1920 x 1080-pixel resolution **color camera** (Wyze v3) with was used.
- A **Raspberry pi** was used to acquire images.
- To take images during nighttime, artificial illumination was used.
- Images were taken **every 15 minutes**.



Leaf wetness detection system with a camera and reference surface

System setup at UF PSREU, Citra



System setup at UF GCREC, Balm

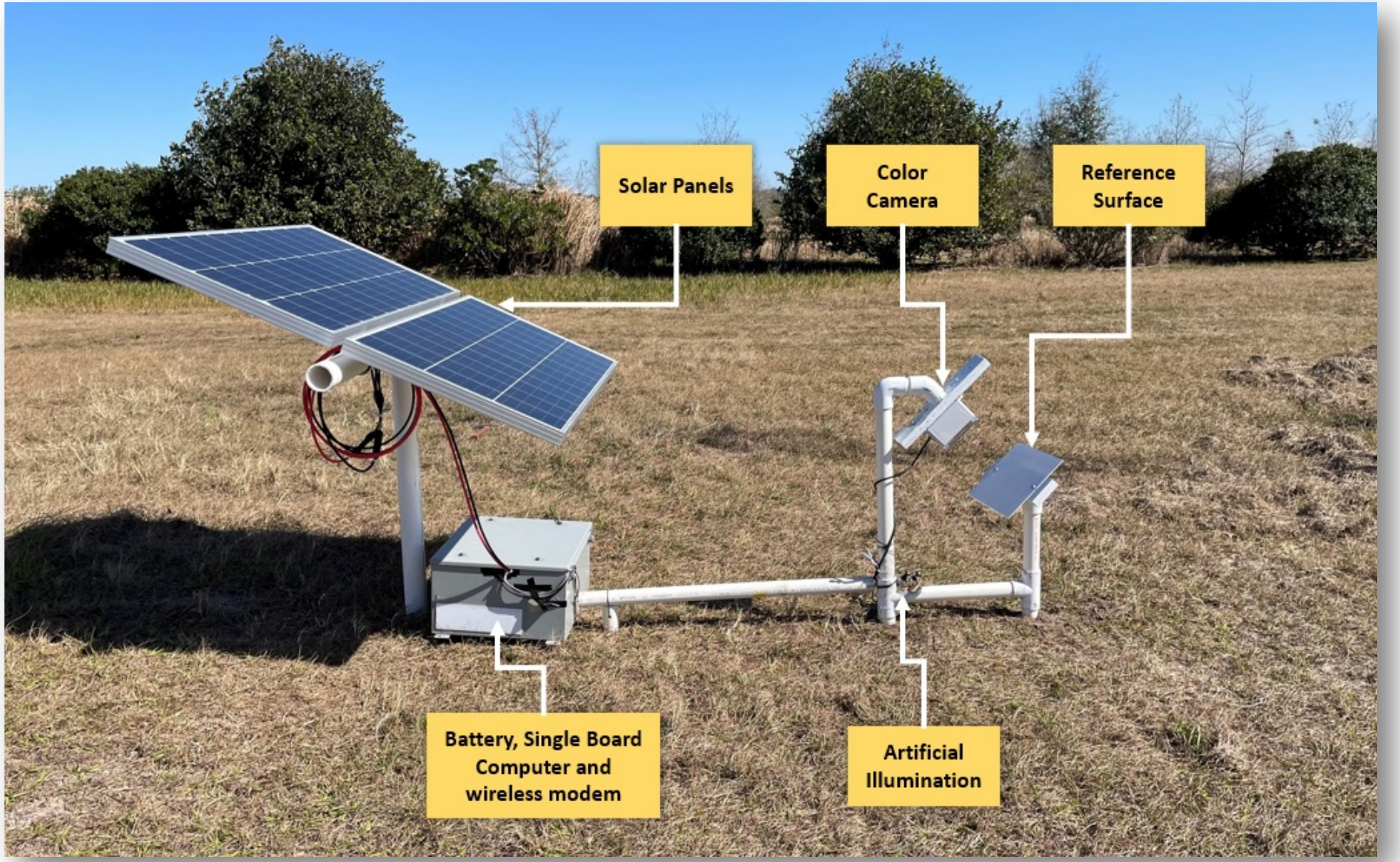
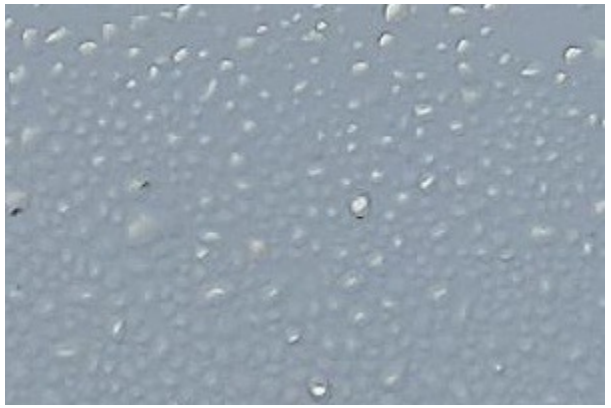


Image Datasets

- Total 19,300 images were collected from October 2021 to March 2022.
- Images were split into 6:4 ratio.
- 11,500 used as training set images and 7,800 as test set images.
- All the images were manually observed and assigned a label either “Wet” or “Dry”.
- If any amount of water was present, then “Wet” else “Dry”.

Example images from the training and test datasets



Daytime Image Under “Wet” Category

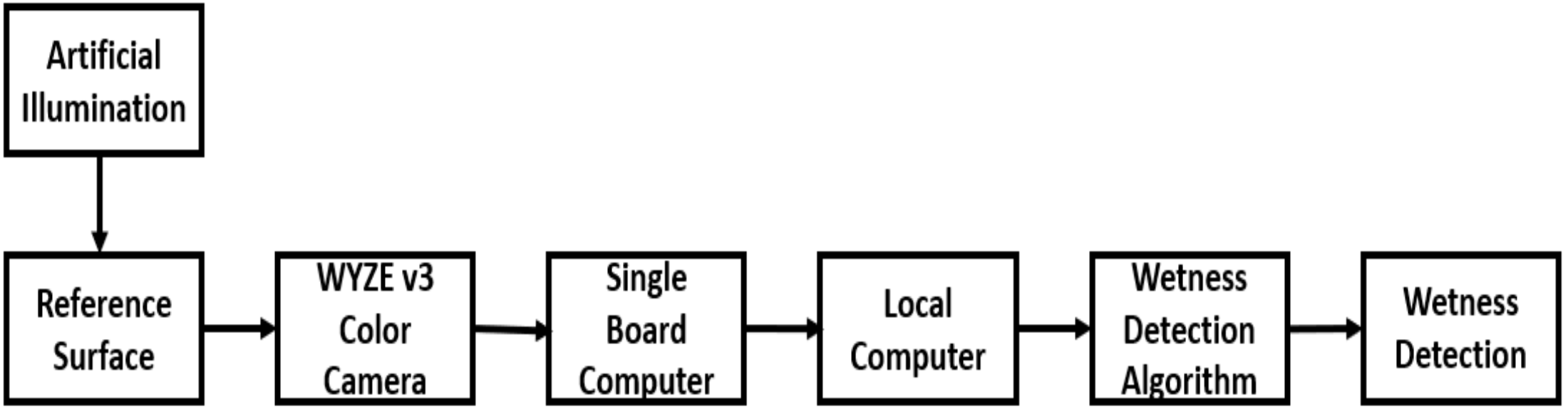
Night-time Image Under “Wet” Category

Daytime Image Under “Dry” Category

Night-time Image Under “Dry” Category

2021-22 Method

- Data collected
  - Citra: October 2021 to March 2022
  - GCREC: February 2022 to March 2022
- Deep learning model was trained
- Wetness was determined after images were collected.



2021-22 Results

Wetness detection accuracy compared with the manual observation

	Citra	GCREC
Accuracy	0.962	0.954
Precision	0.946	0.932
Recall	0.962	0.944

Wetness detection accuracy compared with SAS data

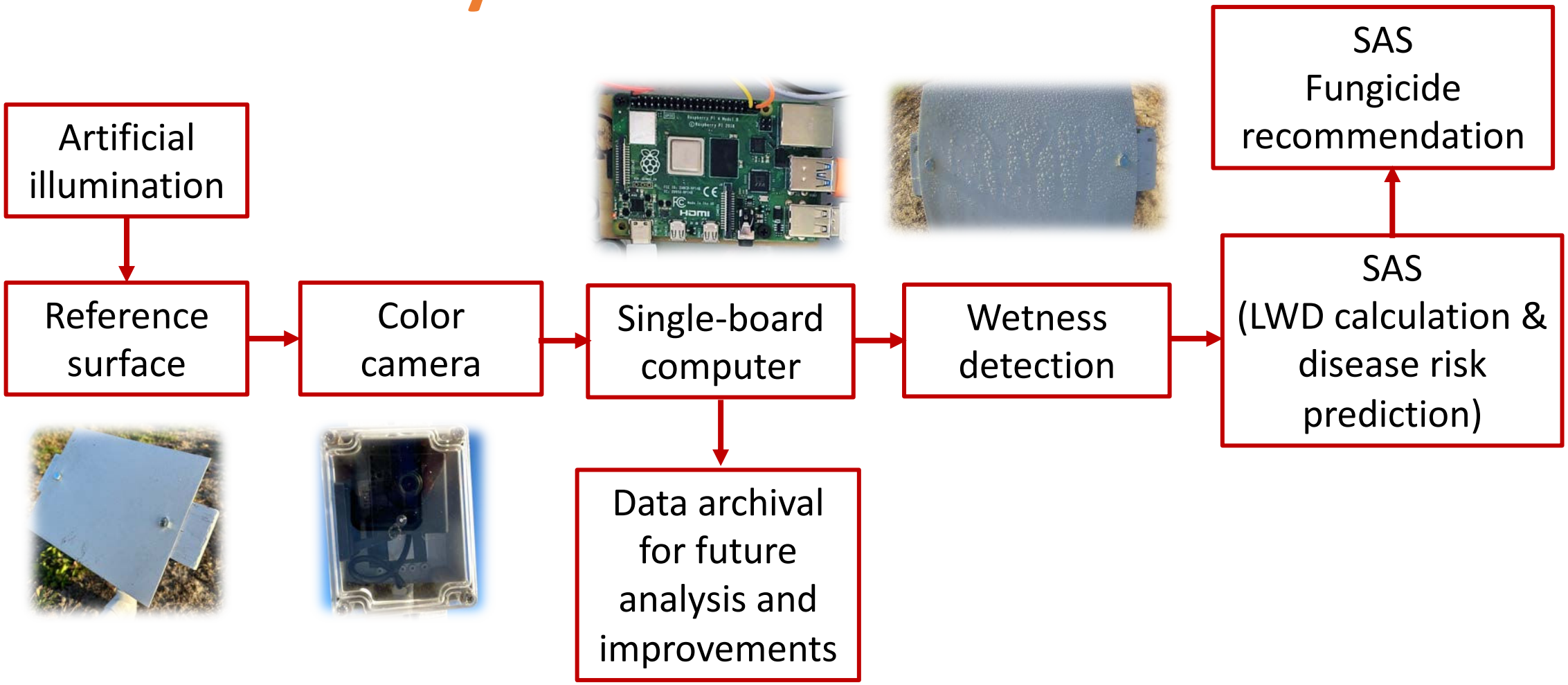
	Citra	GCREC
Accuracy	0.793	0.922
Precision	0.838	0.876
Recall	0.705	0.913

2022-23 Accomplishments

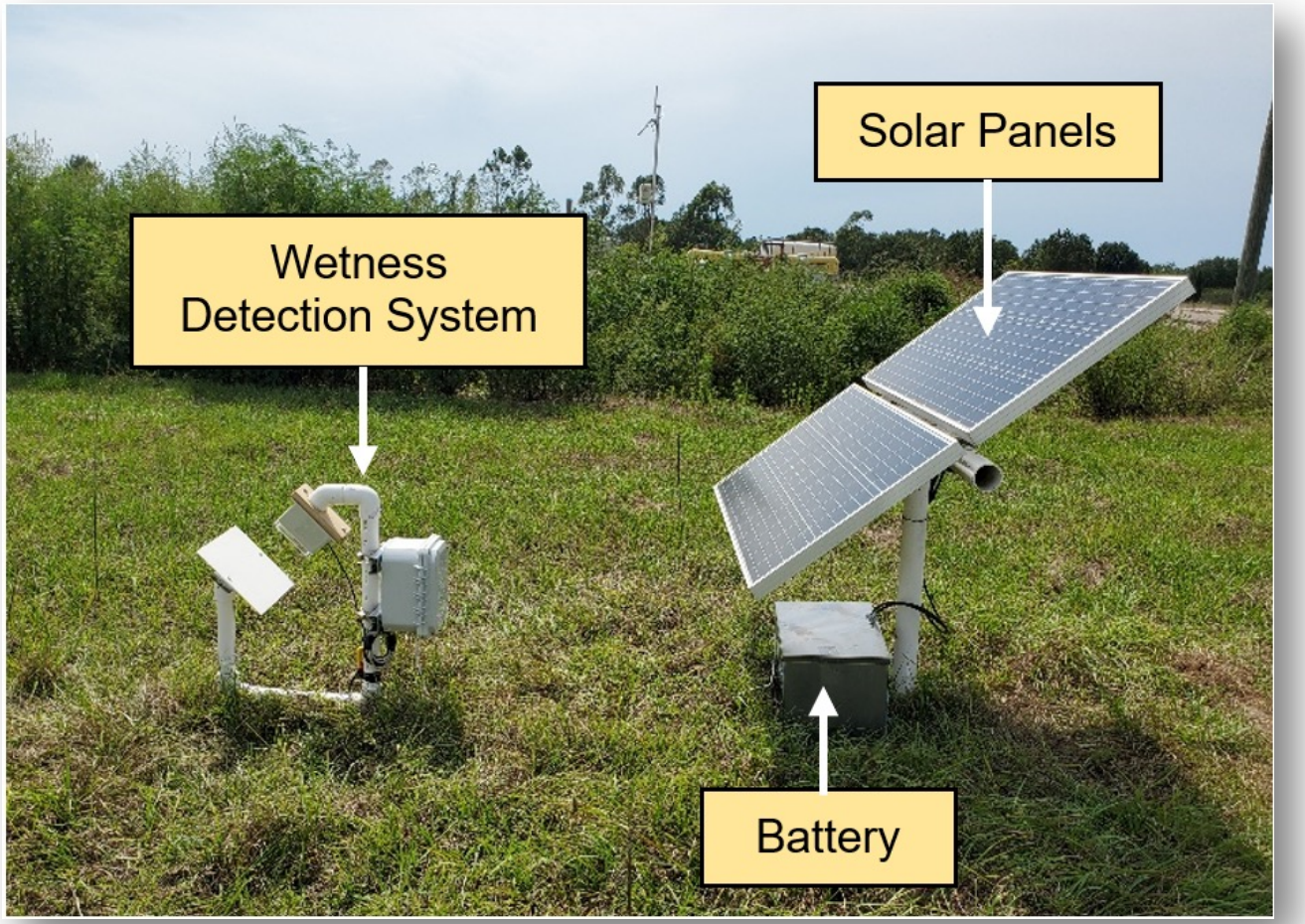
2022-23 Objectives

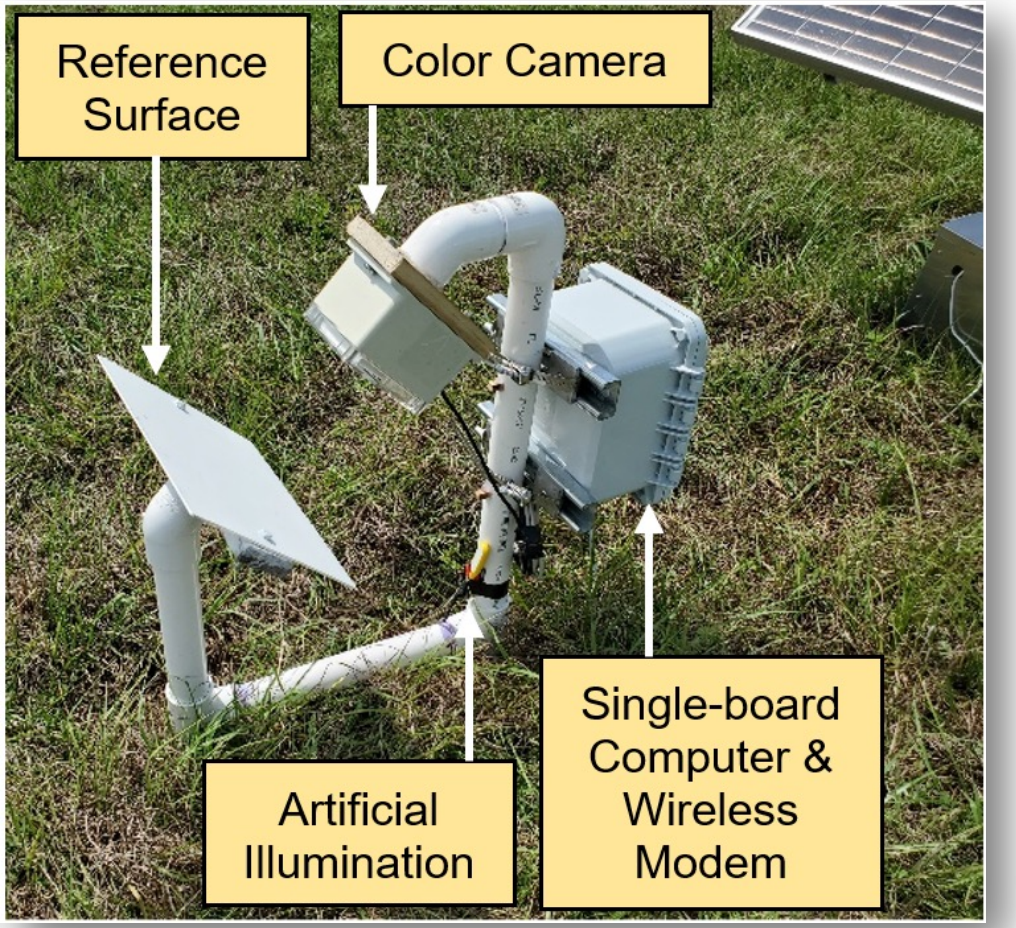
- Overall: To develop a real-time wetness detection system using artificial intelligence
- Specifically,
  - To develop an imaging-based portable, low-cost, and low-maintenance real-time wetness detection system
  - To place this system at three different locations (Citra, Balm, and Dover)
  - To monitor data and compare with the Strawberry Advisory System (SAS)

Block diagram of the new wetness detection system



Real-time plant wetness detection system at GCREC



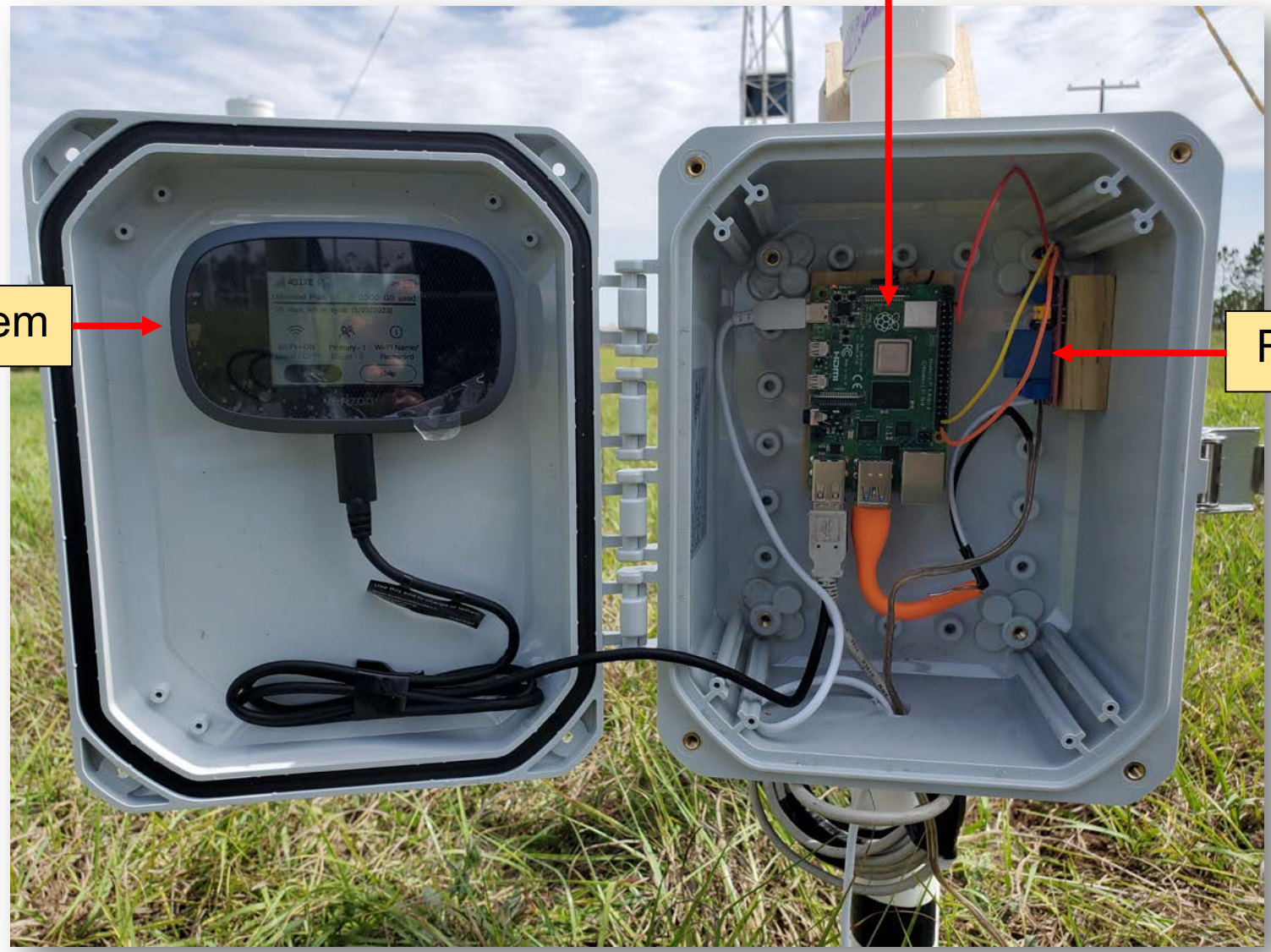


Trained AI algorithm installed

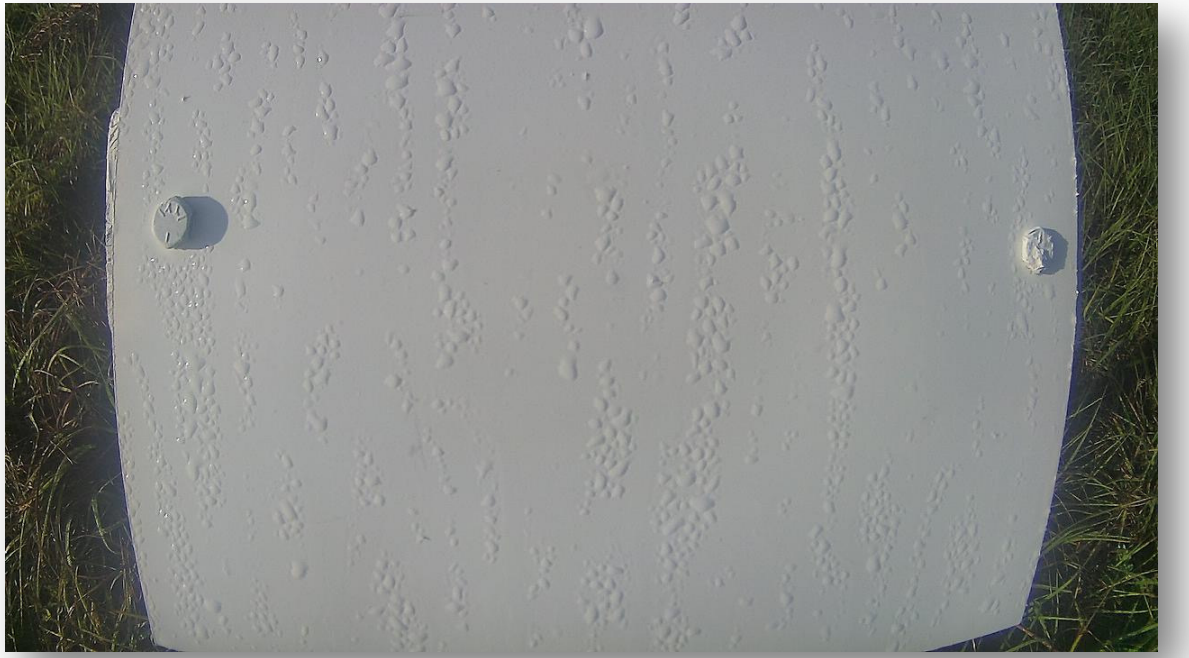
Real-time plant wetness detection system at Dover

Real-time plant wetness detection system at PSREU, Citra

Control box



Results from GCREC

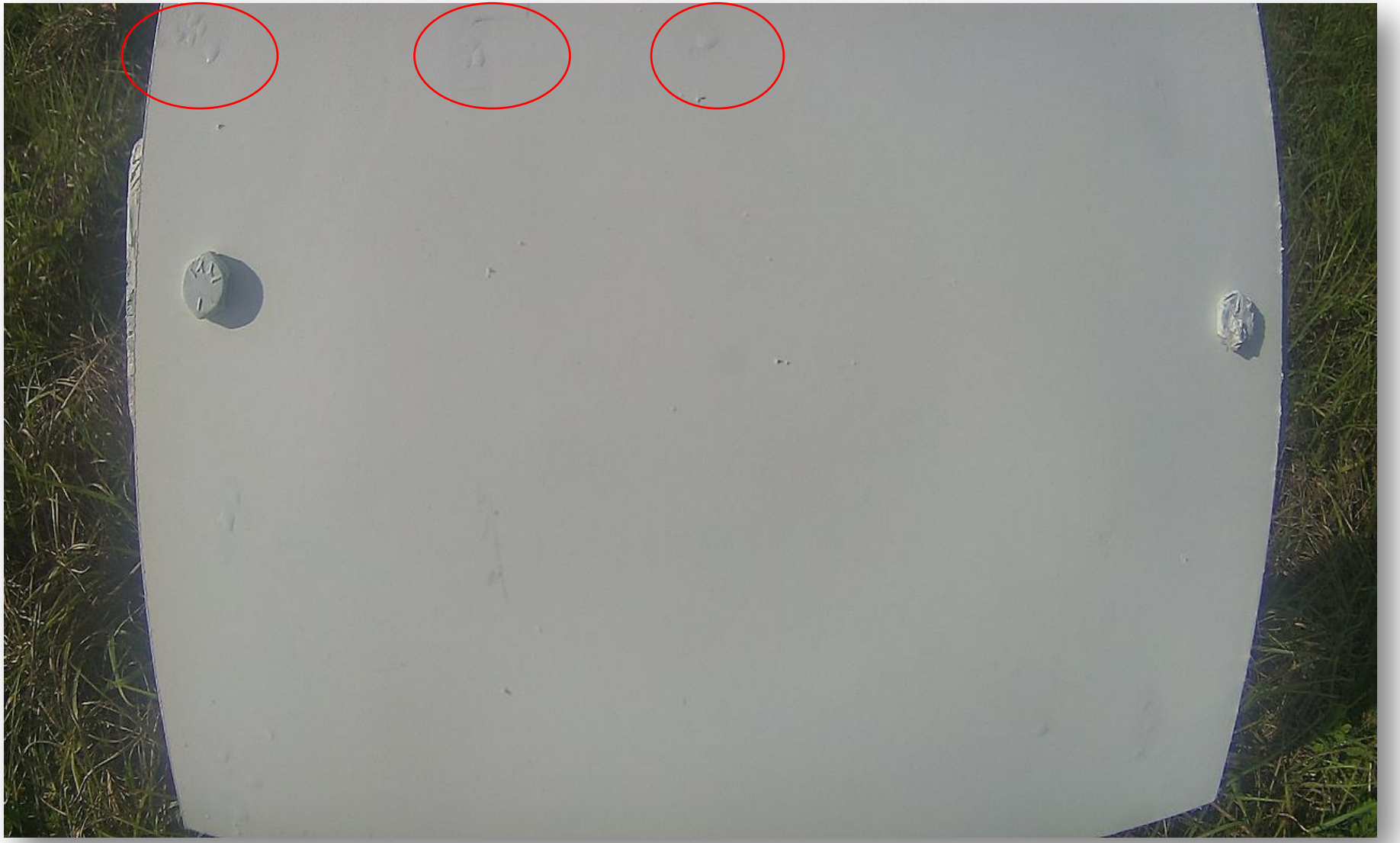


Correctly identified as “Wet”

Correctly identified as “Dry”

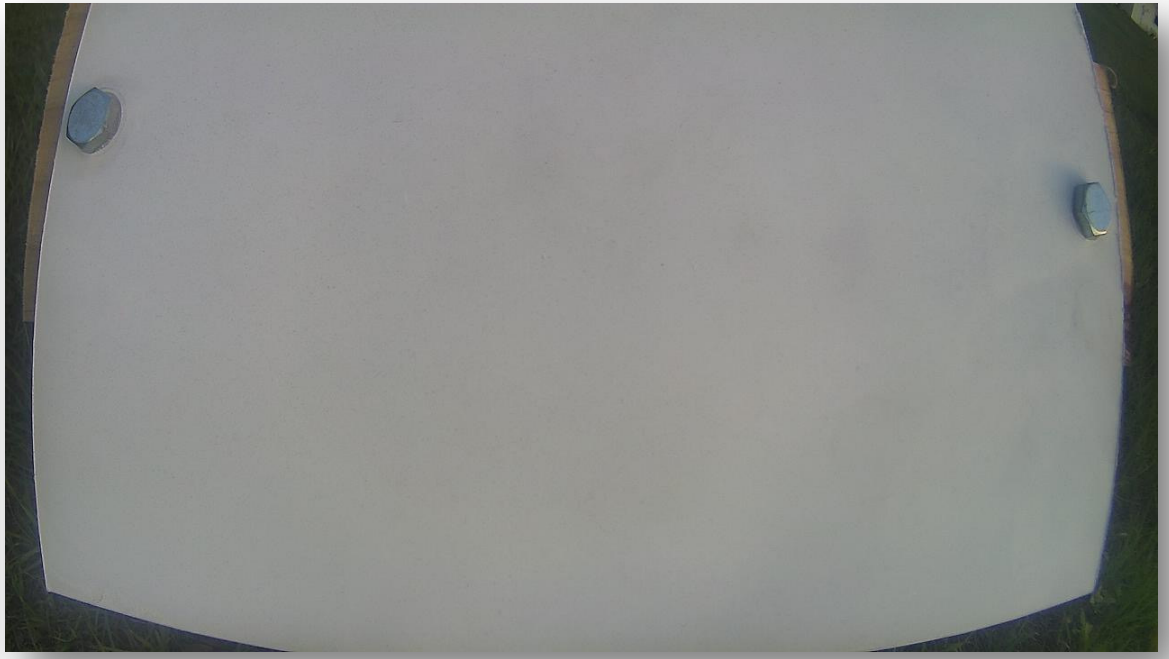
GCREC: incorrectly identified as “Dry”

Water droplets not detected



Results from Dover

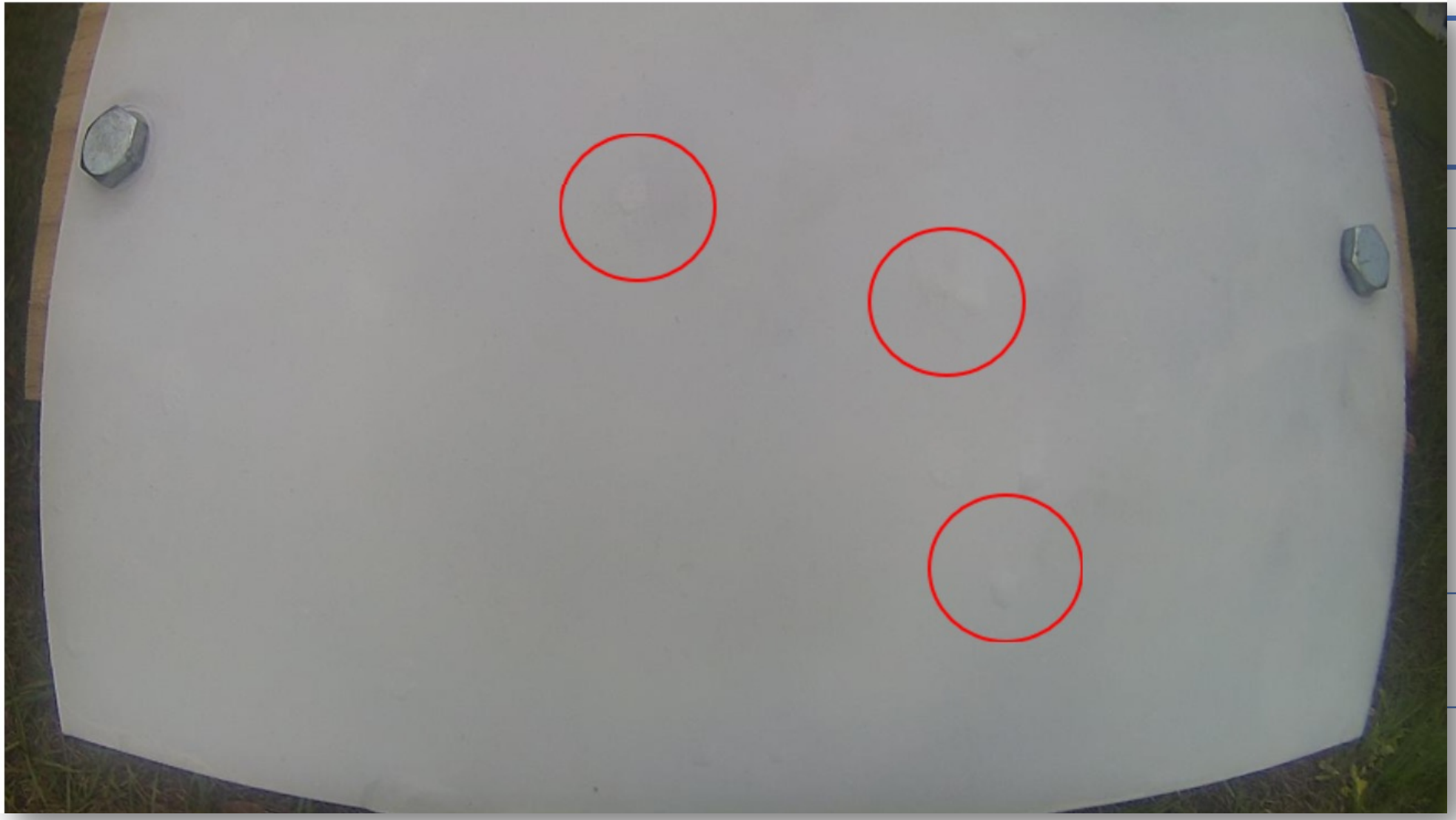
Correctly identified as “Wet”



Correctly identified as “Dry”

Dover: incorrectly identified as “Dry”

Water droplets not visible due to ambient lighting



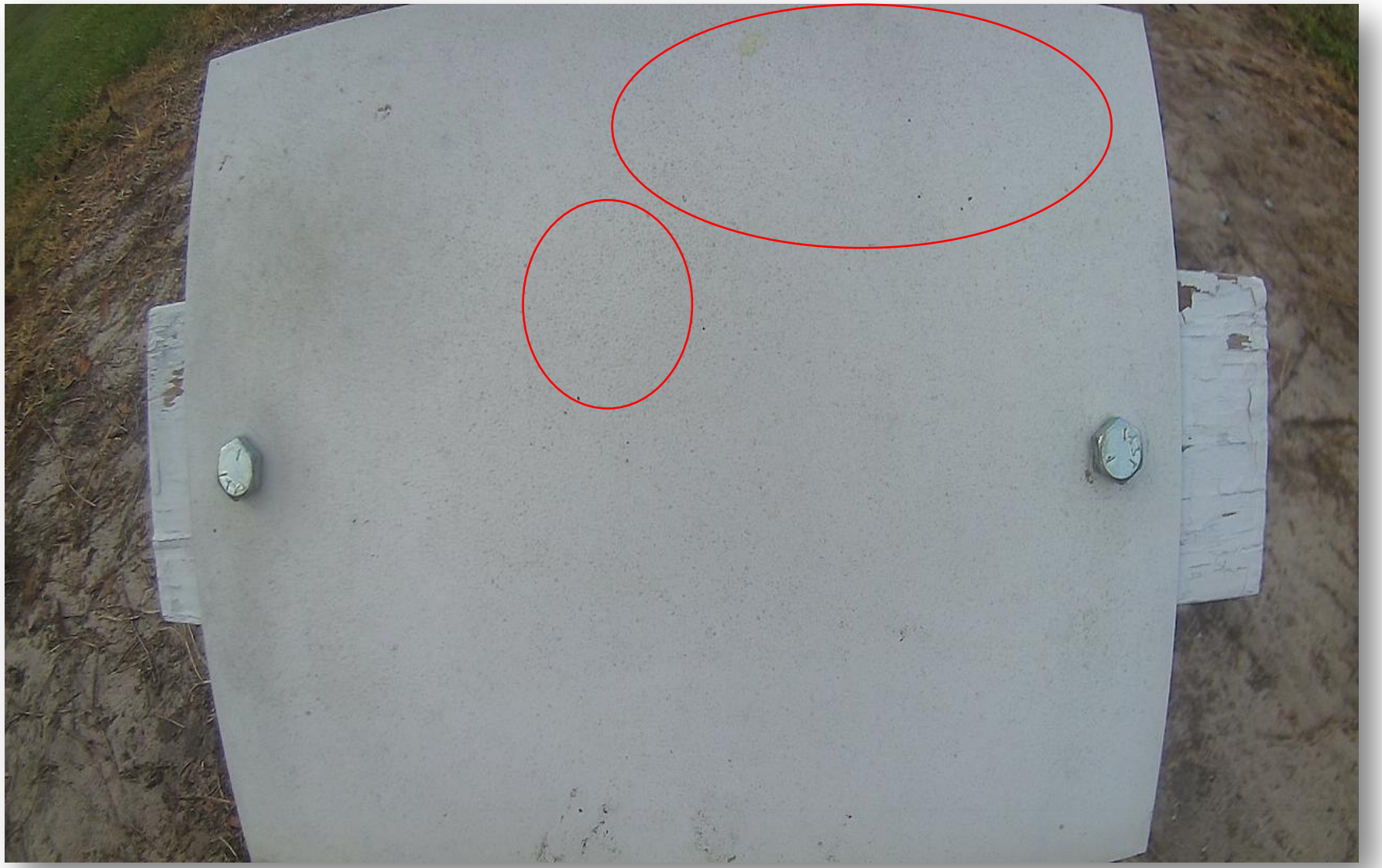
Results from Citra

Correctly identified as “Wet”

Correctly identified as “Dry”

Citra: incorrectly identified as “Dry”

Circled are the areas of formation of dew

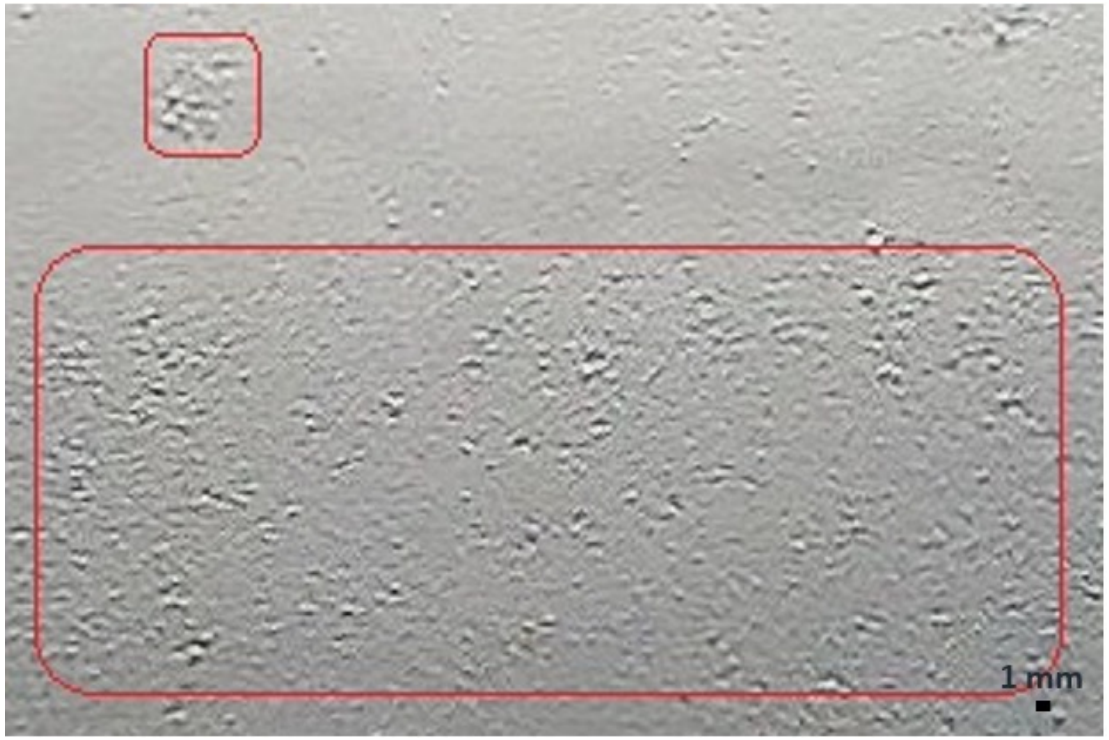


Comparison of the wetness detection results: correlation

- Manual observation vs. Image detection system
- Manual observation vs. SAS
- Image detection system vs. SAS

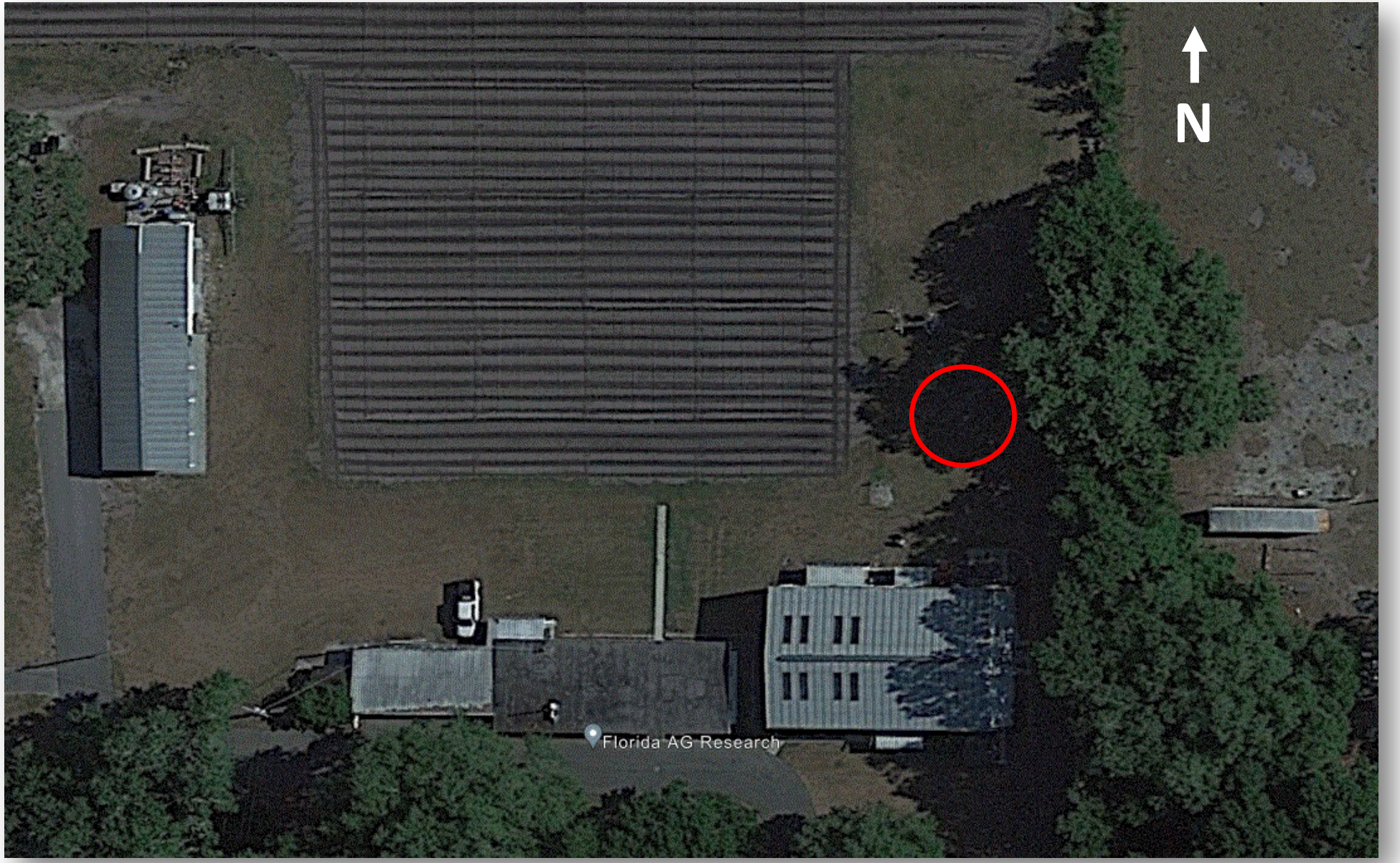
	Citra	GCREC	Dover	All three sites combined
Number of images	1,603	303	1,511	3,417
Manual observation vs. Image detection system	91.3%	90.3%	88.4%	89.9%
Manual observation vs. SAS	89.2%	75.1%	75.4%	81.8%
Image detection system vs. SAS	85.4%	79.2%	67.3%	76.8%

Discussion



Example images of the reference surface with very tiny water droplets during the dew onset period

Discussion: Dover installation



Discussion: Dover installation

Discussion: Dover installation

Discussion: Dover installation

Comparison of Leaf Wetness Duration (LWD)

LWD difference between	Citra	GCREC	Dover	All three sites combined
Manual observation vs. Image detection system	±1 hr	± 1.5 hr	± 1.5 hr	± 1.3 hr
Manual Observation vs. SAS	± 1 hr	± 1.5 hr	± 1 hr	±1.1 hr
Image detection system vs. SAS	± 45 min	± 2 hr	± 2 hr	± 1.4 hr

Summary

- The deep learning method yielded high accuracy.
- During the dew onset period, the water droplets were very tiny (< 0.01 mm), which made it difficult to visually observe those water droplets and categorize and label these images correctly.
- These inaccuracies don't contribute to a significant drop in overall LWD. It contributed to less than ±2 hours in overall LWD for a given day.

2023-24 Plans

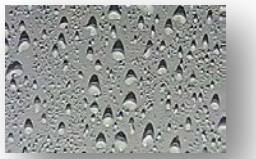
2023-24 Objectives

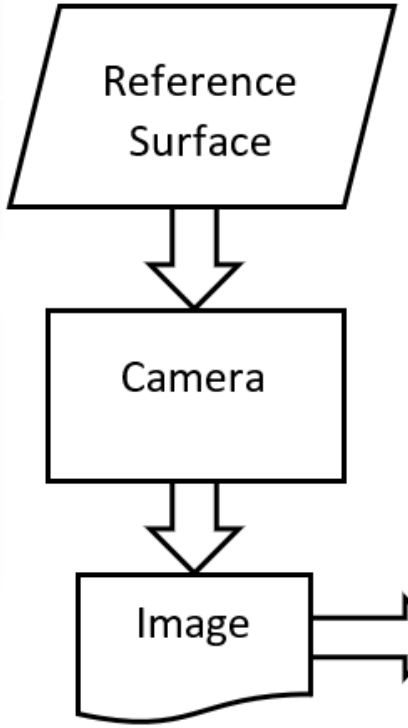
- To expand the system to one more location in Plant City
- To continue to monitor the system's performance over a long period of time
- To compare the results from the image detection system and those from the Strawberry Advisory System (SAS).

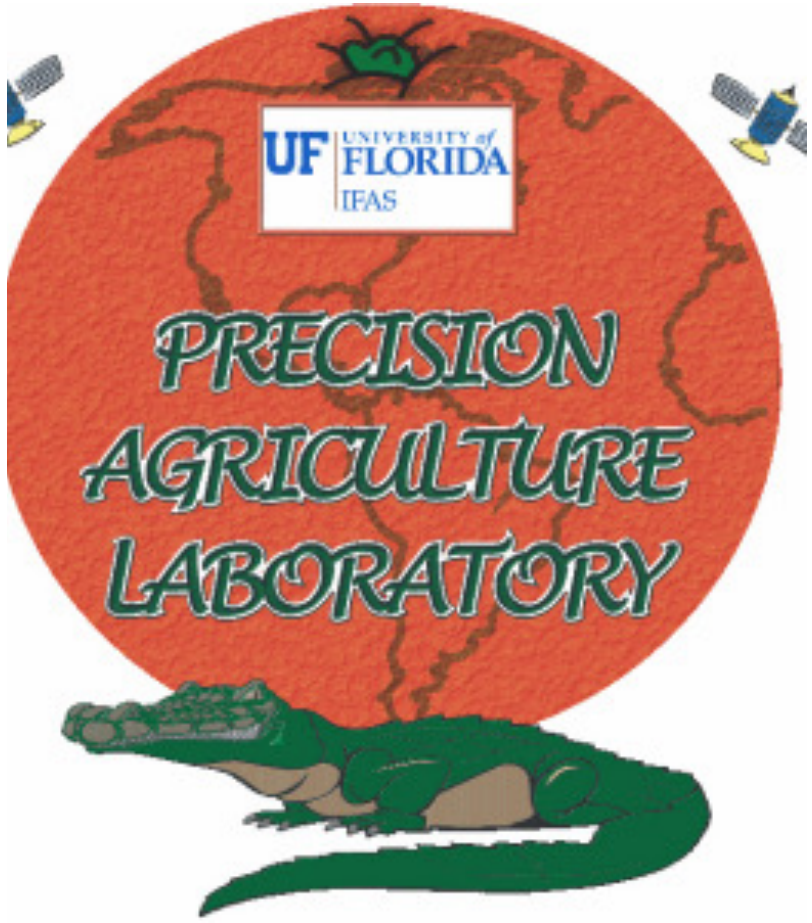
(Source: https://geology.com/satellite/florida-satellite-image.shtml)

Data flow for detecting plant wetness

- Manual observation vs. Image detection system
- Manual observation vs. SAS
- Image detection system vs. SAS







Thank You!

Contact:
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