UAVs IN MULTI-DISCIPLINARY AGRICULTURAL RESEARCH AND OUTREACH: CUTTING-EDGE TECHNOLOGY FOR REAL WORLD CHALLENGES.
WESTERN COLORADO RESEARCH CENTER (WCRC), FRUITA,CO

COLORADO STATE UNIVERSITY EXTENSION

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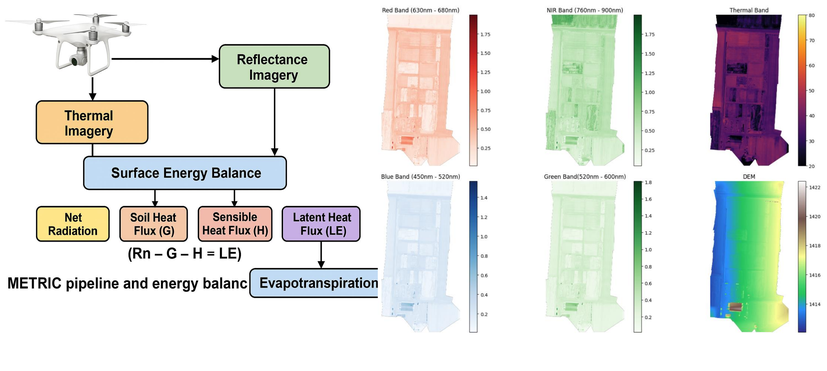
PROJECT INTRODUCTION

This internship took place at the Western Colorado Research Center (WCRC), where the goal was to apply drone-based remote sensing and ground sensor data to estimate evapotranspiration (ET), a key factor in agricultural water use and management.
Using Unmanned Aerial Vehicles (UAVs) equipped with thermal and multispectral sensors, along with data from soil moisture probes, NDVI sensors, neutron probes, and MSR5 weather stations, this project integrated hardware and software solutions to support precision agriculture in water-scarce regions like western Colorado.



INTERNSHIP GOALS

- Gain experience in drone operations and image processing.
- Develop a working ET model using drone and sensor data.
- Automate cloud-based data collection from field stations
- Obtain FAA Part 107 drone pilot certification.

HOW DOES THIS APPLY TO YOUR EDUCATION

This internship aligns with my PhD research in signal processing and automation systems. The experience has enhanced my ability to:

- Design and deploy sensor-driven data systems.
- Develop real-time environmental monitoring tools.
- Bridge theory and fieldwork for real-world impact in agricultural sustainability.

WHAT YOU DID

1. Drone and sensor-Based Data collection

I participated in UAV missions using drones equipped with thermal and multispectral sensors to capture high-resolution images. I also supported the deployment and maintenance of ground-based sensors, including:

- NDVI sensors.
- Temperature probes.
- MSR5 weather stations and Neutron probes.

These instruments collected data on solar radiation, soil moisture, and ambient temperature, which are critical for surface energy balance modelling.

2. Image Processing and Index Calculation

I processed drone imagery to produce:

- Reflectance maps from Red, Blue, Green and NIR bands.
- Vegetation indices like NDVI.
- Albedo maps and Leaf Area Index (LAI).
- Digital elevation Models (DEM).

These products were generated using Python-based tools and GIS software.

3. Evapotranspiration Estimation Code development

I was able to complete and test a Python-based ET model. This model implements the METRIC approach, calculating:

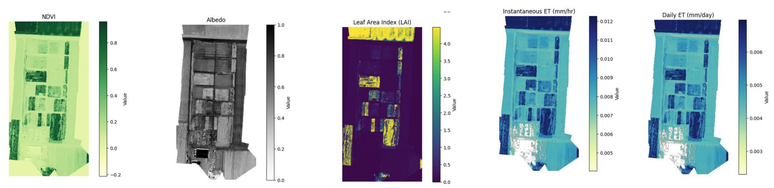
- Net Radiation (Rn)
- Soil heat flux (G)
- Sensible heat flux (H)
- Latent heat flux (LE)

From LE, I derived instantaneous ET (mm/hr) and daily ET (mm/day) maps.

4. Telemetry System Setup

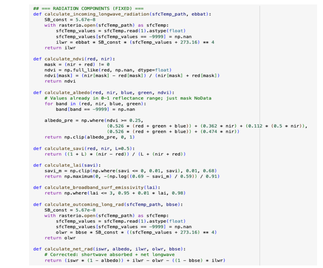
I also led the setup of a wireless telemetry system using:
Campbell Scientific CELL205 modems with T-mobile sim cards, RF407 radios and CR1000X dataloggers.
This system collects environmental data from field stations and uploads it to the cloud for remote, real-time monitoring.

Figure 1. (image)



WHAT YOU LEARNED

- Remote sensing and image analysis: including multispectral/thermal image correction and vegetation indices.
- Python modelling: implemented a full evapotranspiration estimation workflow based on surface energy balance.
- Telemetry systems: Gained experience in RF communication, sensor networking, and cloud integration.
- Interdisciplinary collaboration: Worked across domains including agriculture, civil, hydrology and telecommunication engineering.
- Obtained my FAA drone pilot license.



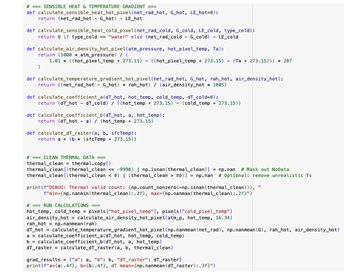


Table 1.

Parameter	Mean	Min	Max	Units
Surface Temperature (Ts)	36.0	18.0	51.0	°C
Net Radiation (Rn)	520.0	400.0	650.0	W/m²
Soil Heat Flux (G)	45.0	20.0	80.0	W/m²
Sensible Heat Flux (H)	150.0	50.0	300.0	W/m²
Latent Heat Flux (LE)	325.0	250.0	460.0	W/m²
Instantaneous ET (ET_inst)	0.48	0.3	0.68	mm/hr
Daily ET (ET_day)	5.2	3.8	6.9	mm/day
ETr Fraction (ETf)	0.8	0.55	1.1	unitless
Latent Heat of Vaporization (L)	2.45		nan	MJ/kg
Hot Pixel Temp (mean)	46.4	≥45.3	nan	°C
Cold Pixel Temp (mean)	18.2	≤19.6	nan	°C

NEXT STEPS

- Improve the Python-based METRIC model for greater stability and robustness.
- Refine incoming shortwave radiation (ISWR) calculations to reduce input uncertainty and produce more accurate ET estimates.
- Validate and scale the ET model across more datasets and crop types.
- Finalize full deployment of the telemetry network.
- Collaborate with CSU Extension to support training and outreach.
- Explore peer-reviewed publication of the ET pipeline.