Key Findings from Floating Solar Research Project

Oct 24,11.40 AM Eastern, 2024

Manjunath Matam

FSEC – UCF

manjunath.matam@ucf.edu

Rebecca R. Hernandez

UC Davis

rrhernandez@ucdavis.edu

Emma Forester

UC Davis

ekforester@ucdavis.edu

UCF

Agenda

- Background
- Project details
- What we found

Great support from Team and Partners

Project team

Institution	Name
FSEC-UCF (Lead)	Colleen Kettles (PI)
	Manjunath Matam (Co-PI)
	Dave Chasar (Co-PI)
	Donard Metzger
Wild Energy Center, UC Davis	Rebecca R. Hernandez
	Alex Cagle, Ph.D. Emma Forester, Ph.D. Candidate
NREL	Bill Sekulic Dirk Jordan
OUC, Orlando	Paul Brooker

Floating site partners

Site
Orlando Utilities Commission, FL
Altamonte Springs, FL
Windsor Water Treatment Facility, CA
Far Niente, Oakville, CA

Background:

- Floating PV modules operate cooler?
- More power production compared to Land installed PV system?
- Do floating systems impact water bodies and their ecology, and vice versa?

Floating PV (FPV)

A 1.2 MW Floating Solar PV System, Orange County Utility, Orlando, Florida (Pic for representation purpose only)
Pic source: https://d3energy.com/orange-county-srwsf

Project info.:

- **Title:** Quantifying and Valuing Fundamental Characteristics and Benefits of Floating Photovoltaic (FPV) Systems
- **Sponsor**: SETO, US Dept. of Energy
- **Funds**: $1.1 M (20% cost share)
- **PP**: 2020 Mar. – 2024 May
- **Goal**: Study the ecological impacts; collect and analyze FPVs temperature and performance data; publish data.

UCF

Project sites:

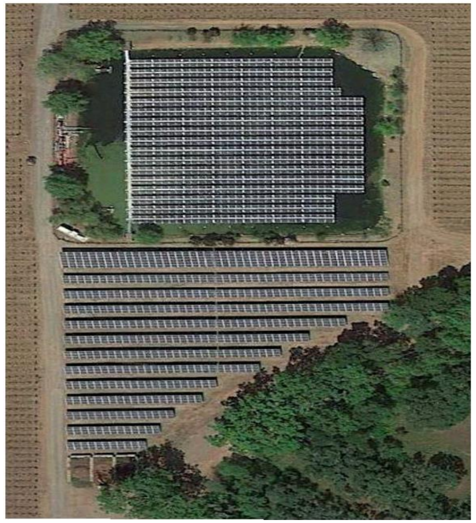
- Studied four floating PV sites

Pic credits: Google image

Altamonte Springs, FL
960 kW, Storm Water Pond,
DC/AC 1.16

OUC Orlando, FL
32 kW, Storm Water Pond

Windsor, CA
1.78 MW, Water Treatment,
Surface covered 22%



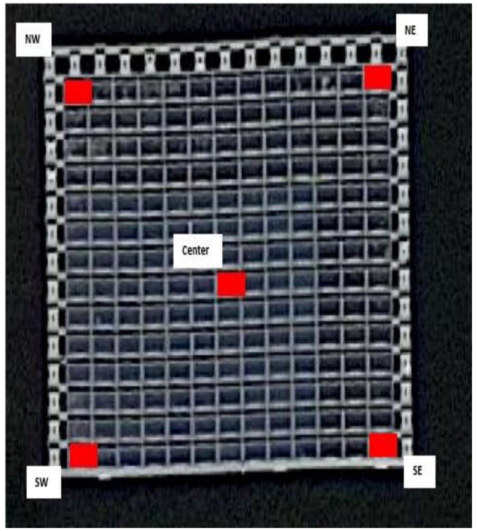
Far Niente Winery,
Oakville, CA; 200 kW
FPV, 278 kW LPV,
Irrigation pond,
surface covered >90%

- Common features:
  - Monofacial modules and Floating arrays facing south
  - Each floating system tied to a land PV system for comparison

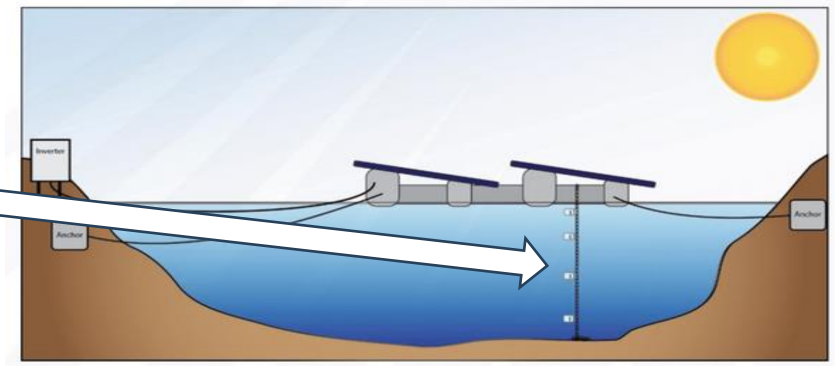
Project sites:

- Data collected in last 2 years

Pic credits: Google image



- Data collected:
  - Time-series (1-5 min frequency)
    - Modules temperature, Water temperature
    - Inverter data, Weather data
  - Manual approach
    - Water ecology studies

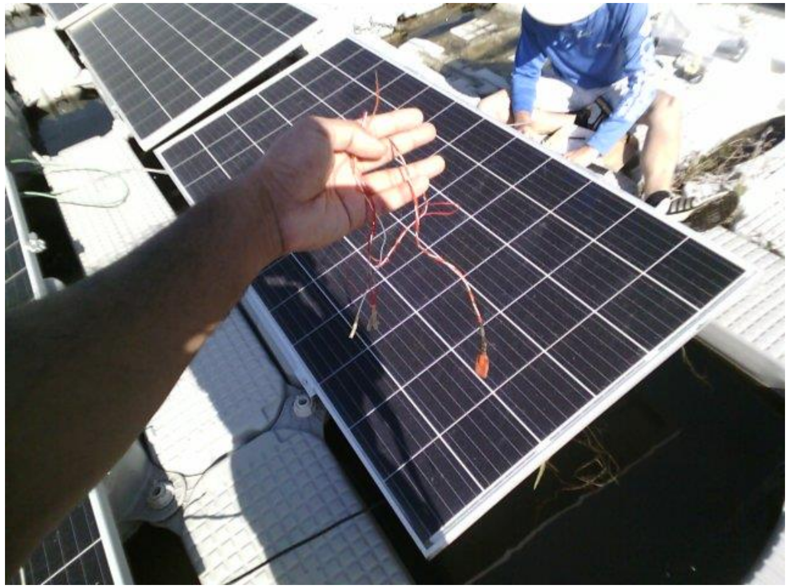


Challenges Overcome:

- At sites

You need a boat to float

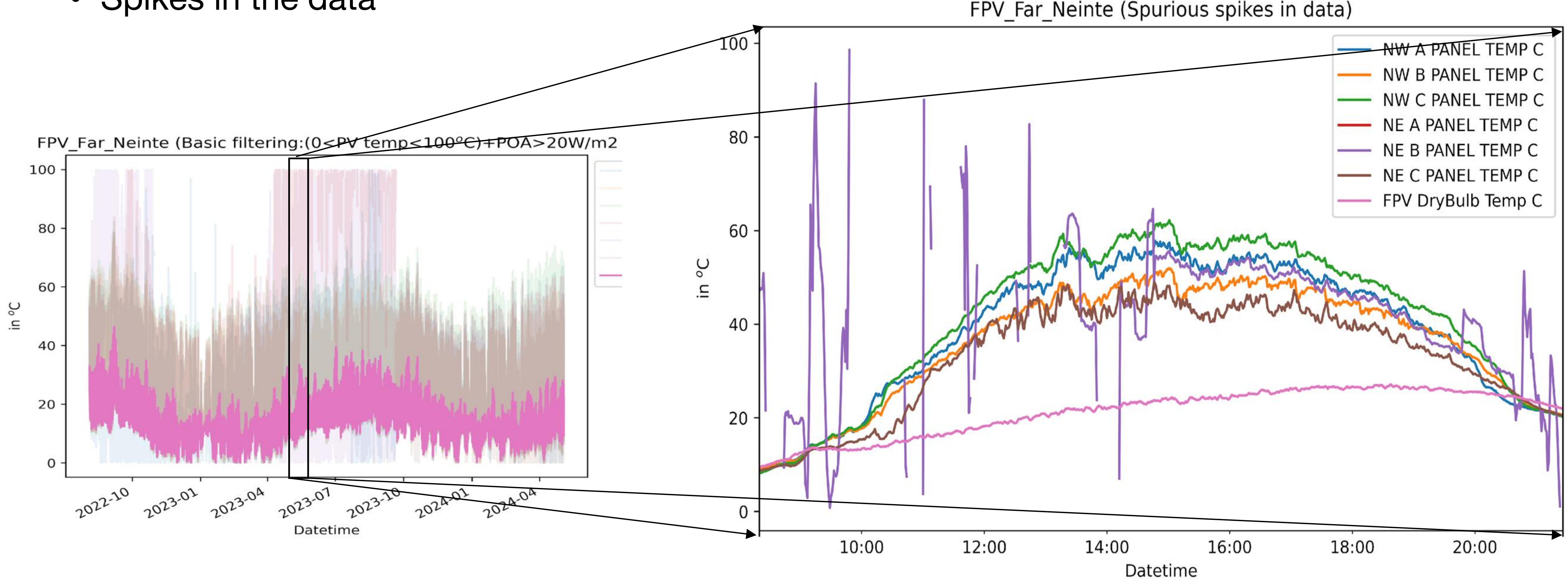
Walking on floats is always challenging



Animals do work with our sensors

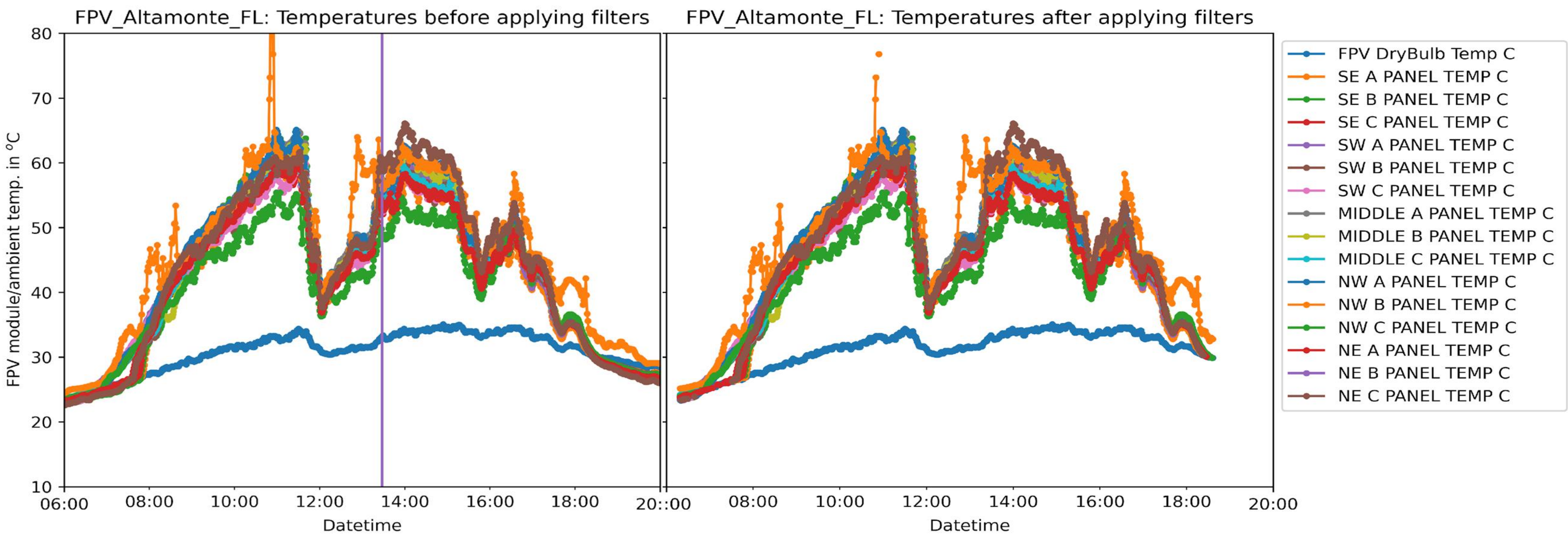
Challenges Overcome:

- Spikes in the data



Challenges Overcome:

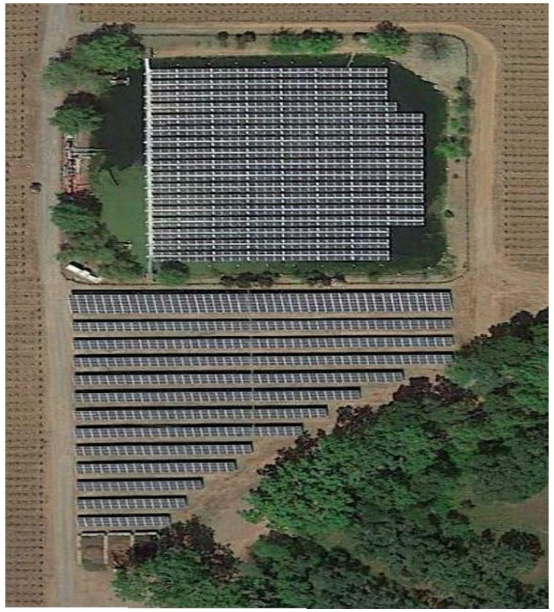
- Spikes in the data

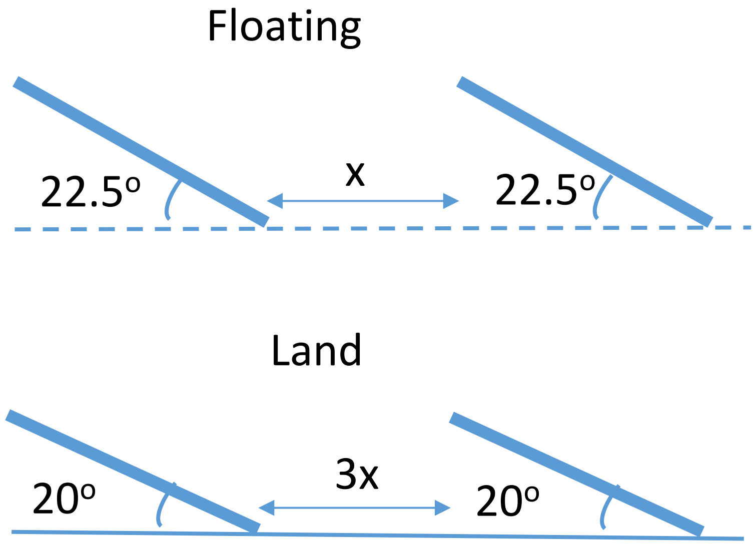


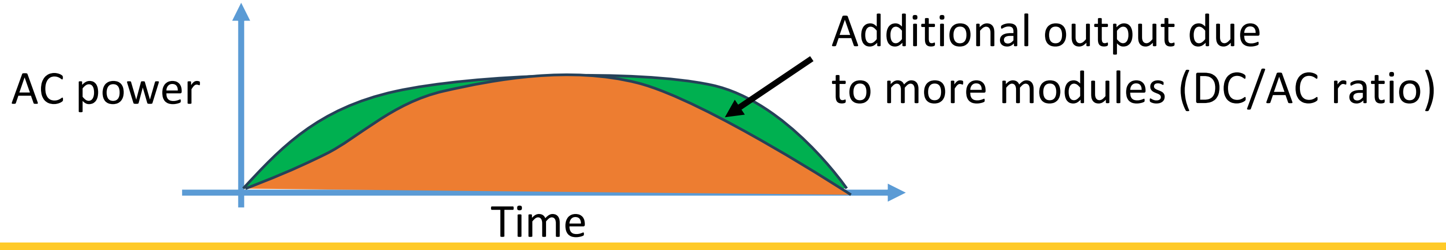
UCF

Oakville Site: A True Apples-to-Apples Comparison?

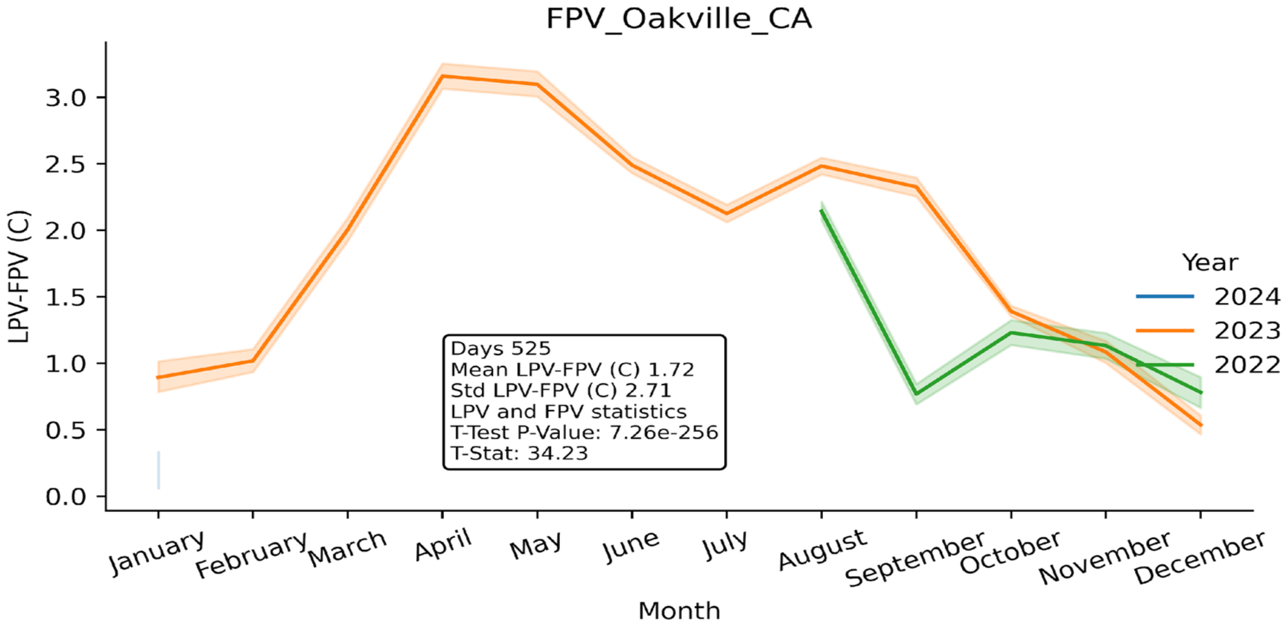
- No
- The design favours land system due to
  - Three times more spacing between rows
  - Less inclination angle
  - More PV modules per inverter







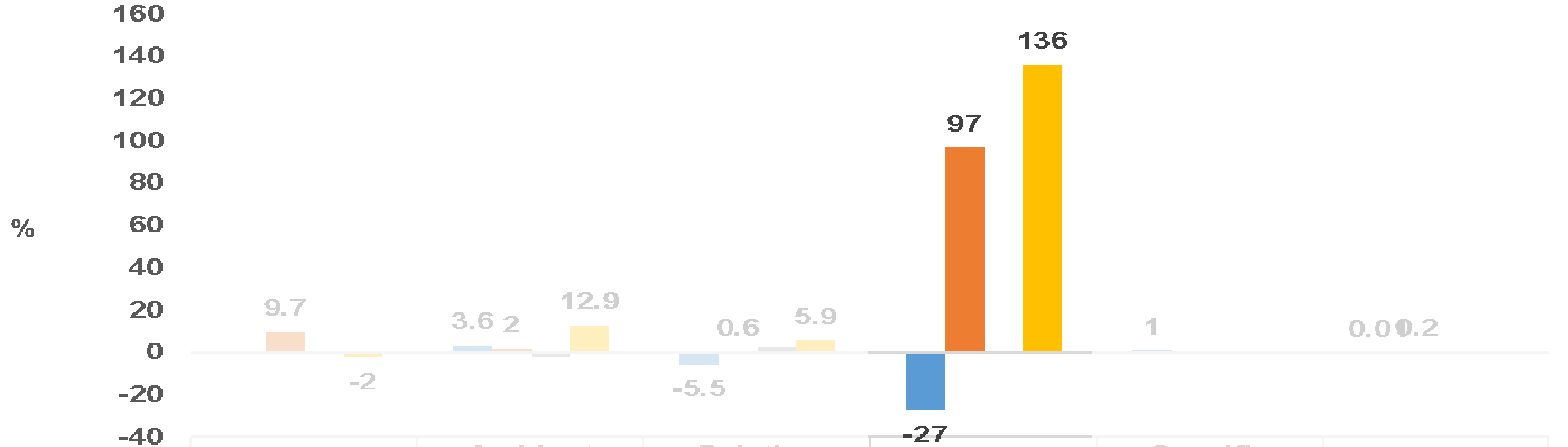
Find-1: Floating modules operate cooler



- On avg., 1.72 °C cooler (std 2.71 °C) compared to Land modules.
- An avg. 0.69% more efficiency or production.
- This site has custom built floating structure.

Find-2: More wind on floating arrays

Floating environment compared to nearby adjacent land:



	Irradiance	Ambient Temperature	Relative Humidity	Wind Speed	Specific Enthalpy	Air Pressure
Altamonte		3.6	-5.5	-27	1	0.01
Orlando	9.7	2	0.6	97		0.2
Oakville	0.03	-2	3	0	-0.1	-0.007
Windsor	-2	12.9	5.9	136		

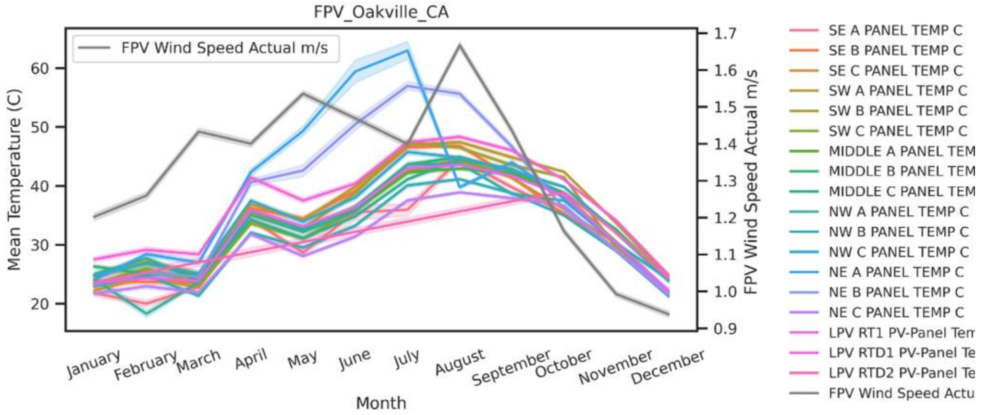
Meteorological parameters

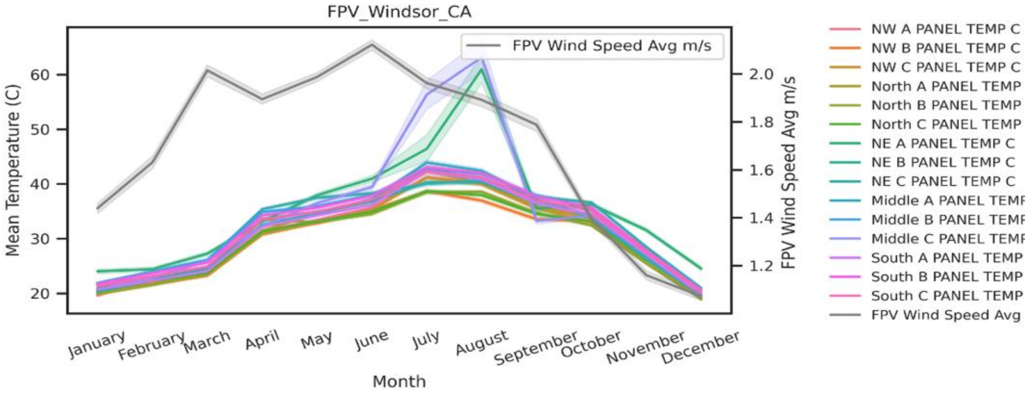
Altamonte Orlando Oakville Windsor

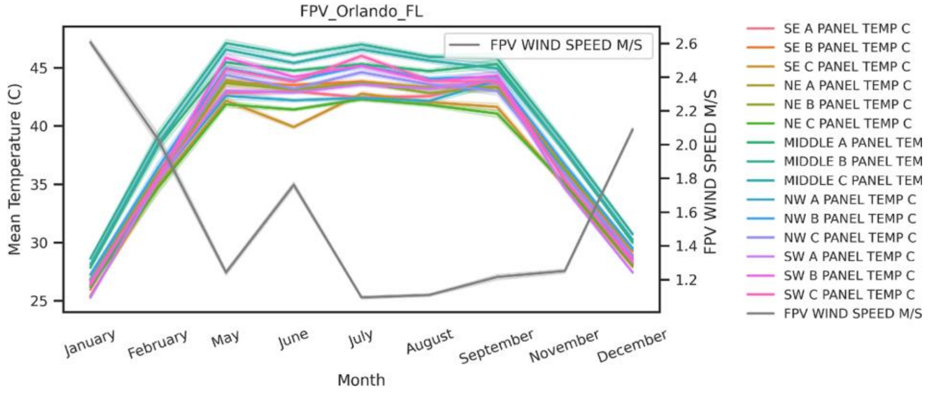
UCF

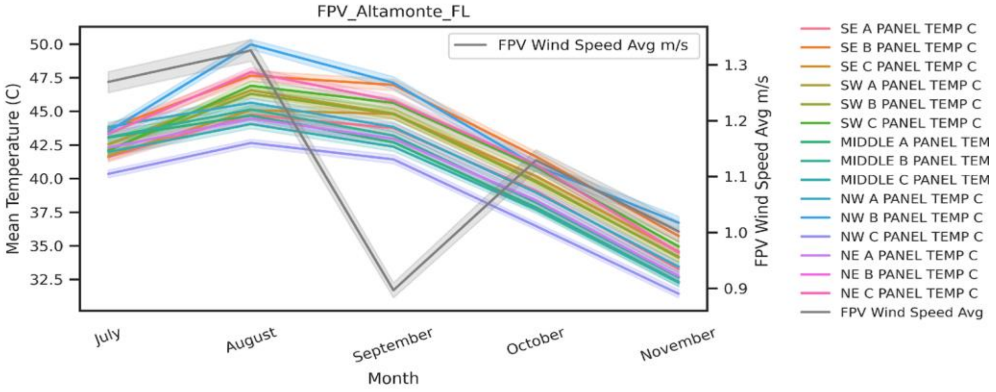
Find-3: Floating modules have high delta

- This means, there is a significant temperature difference between the modules at any given moment.







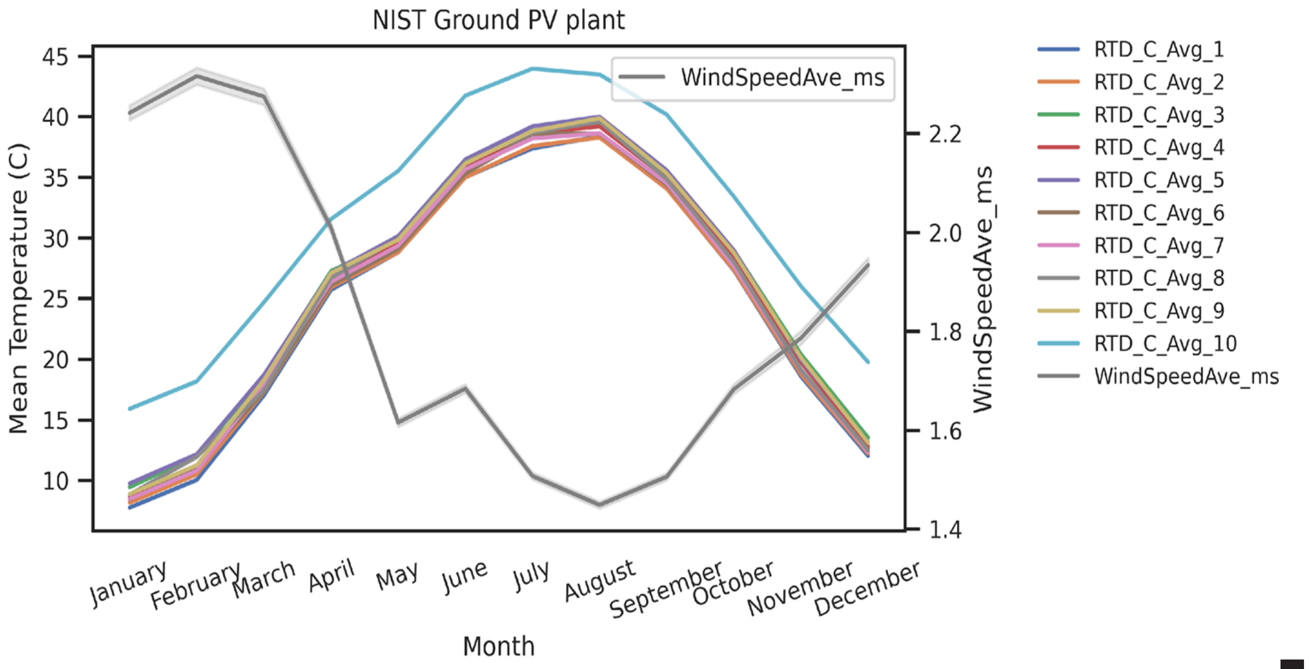


UCF

What about Land installed PV modules?

- Same analysis was done for an open-source dataset by NIST.
- 271 kW land installed PV system, 3 years data, 1 min resolution, 9 PV modules temperature.

NIST Ground mounted PV array located in Gaithersburg, MD.



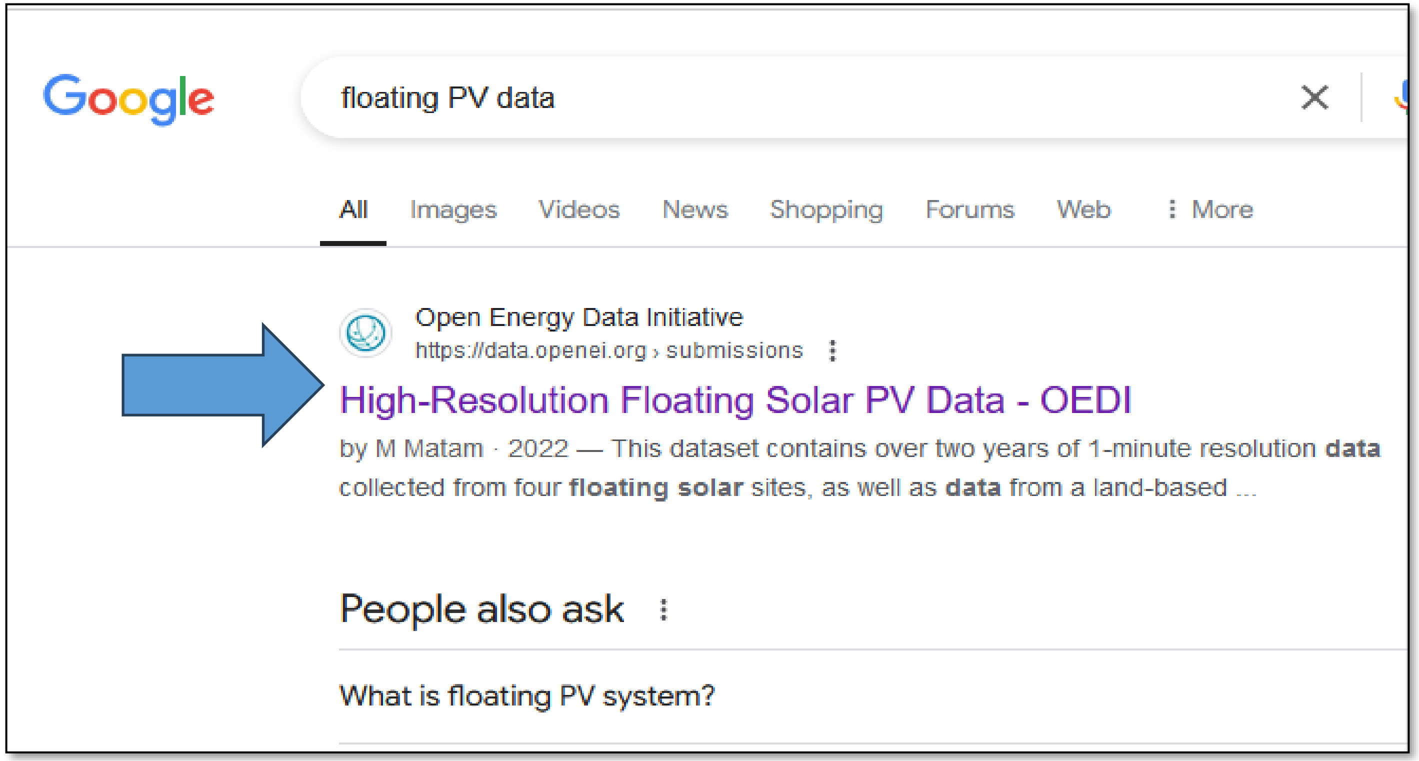
Find-4: Bird droppings could be an issue

- Windsor site pics from 2023 September visit.
- Site was in operation for 3 years
- More bird droppings on the North/South most modules (?)
  - Does the type of pond and neighboring trees impact this?
  - Does it impact the performance?: *Yes! significant bird droppings reduce the PV output by a high percentage. How much impact?*

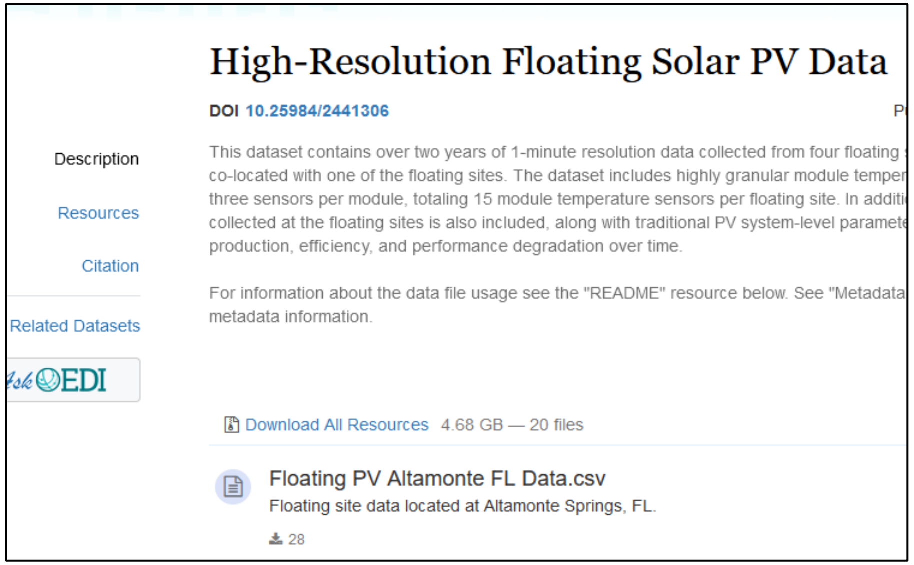
UCF

You can access data:

Google it: floating PV data



Landing page



UCF

Ecological Study Results

Rebecca R. Hernandez and Emma Forester - Wild Energy Center

UC Davis

Aligning floating photovoltaic solar energy expansion with waterbird conservation (under review)

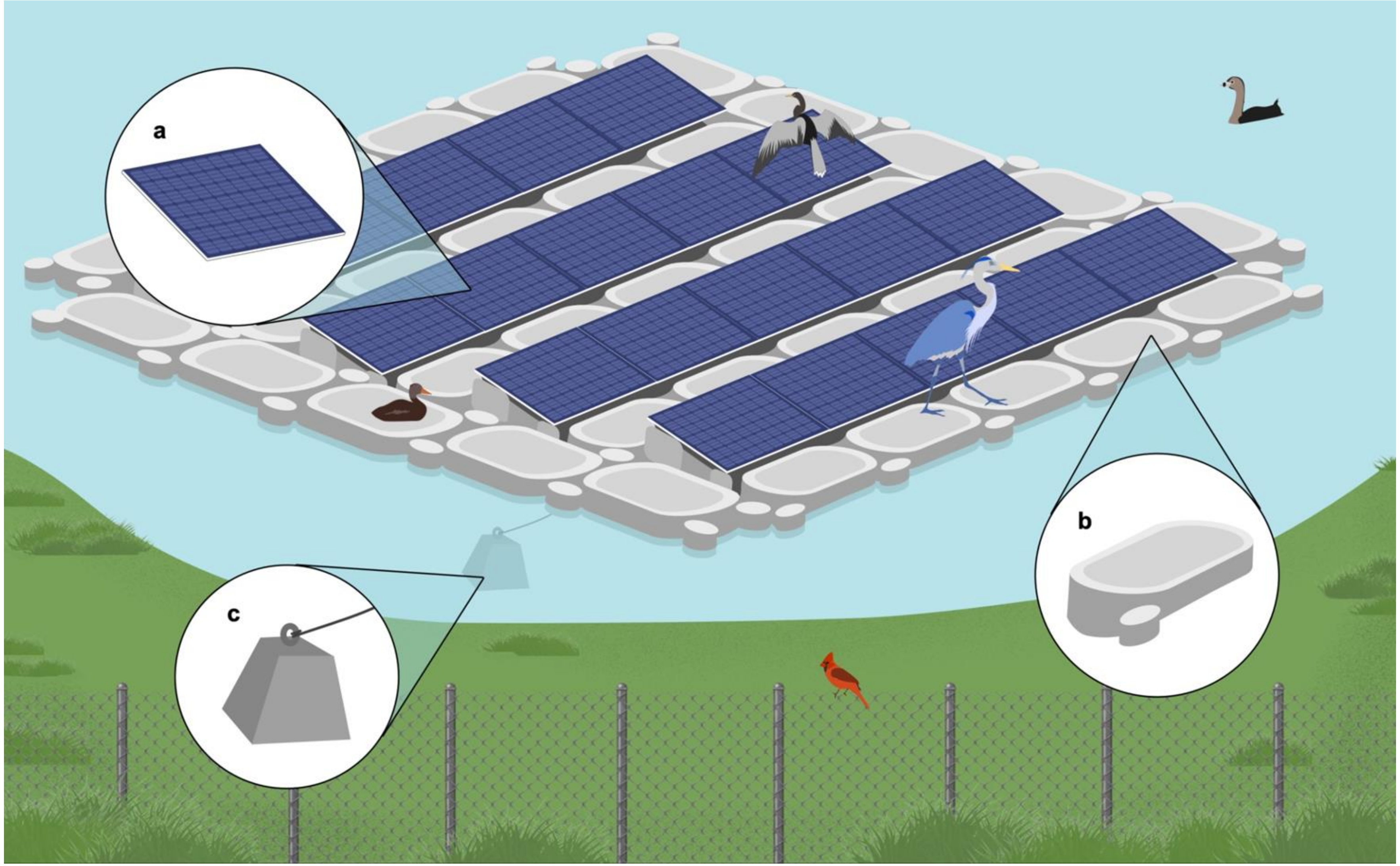


Fig. 1: Floating photovoltaic structures (FPVs) have three distinct elements.

Waterbirds serve as a compelling model study system to conceptualize FPV-wildlife interactions given their potential to interface with FPV infrastructure above and below the water surface (Fig. 1), accessibility to monitor in the field, and the global-scale concern for waterbird conservation.

UCF

We provide a comprehensive overview of the role of waterbirds as representative taxa for understanding the interplay between FPVs and wildlife by identifying and discussing five key concepts to consider and apply to the development and operation of FPVs globally, including potential concessions for conservation.

Specifically, we posit that

1) Floating photovoltaic solar energy represents novel aquatic infrastructure that may be used by waterbirds,
2) Impacts are exchanged among waterbirds, their habitat, and FPVs, including impacts on PV performance and durability,
3) The siting, design, deployment, and operation of FPVs may include concessions for waterbird conservation,
4) Unique waterbird monitoring and survey approaches are needed at FPV sites, and
5) Long-term impacts of FPVs on waterbirds are possible, including the transport of FPV-driven plastics and other materials across food webs.

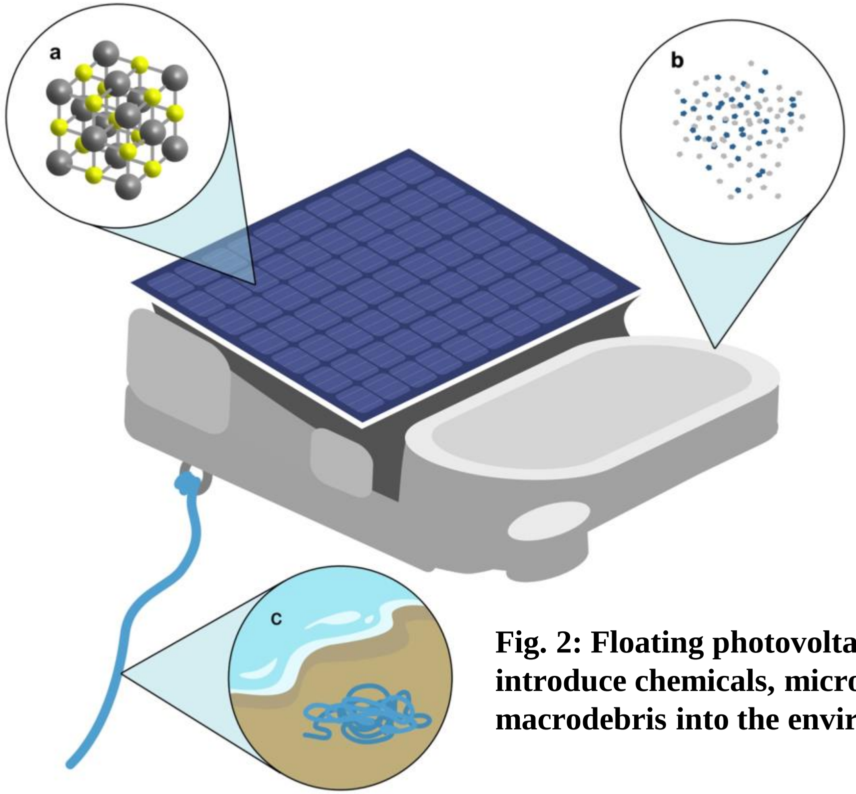
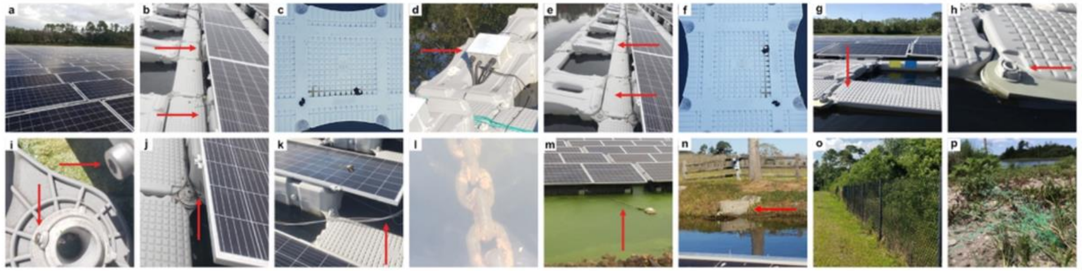


Fig. 2: Floating photovoltaics may introduce chemicals, microplastics, and macrodebris into the environment.

UCF

Potential Risks and Benefits to Waterbirds

Novel Floating Solar Energy Components		Potential Risk					Potential Benefits									
							Foraging			Maintenance				Reproduction		Sociality
		Collisions	Degradation of materials	Snagging/Choking	High Thermal Temperature	Electrical Shock	Ambushing/Stalking	Hawking/Sallying	Gleaning	Resting/Loafing	Perching	Drying	Preening	Courtship/Mating	Nesting	Social Interaction
Primary	PV Panel (a)	●	●		●	●	●	●	●	●	●	●	●	●	●	●
Primary	PV Mounted Racking Main HDPE Float (b)		●						●						●	
Primary	Non-racking Main HDPE Float (c)		●				●		●	●	●	●	●	●	●	●
Primary	Combiner Box (d)		●					●	●		●	●	●			
Secondary	Racking Main HDPE Float (e)		●				●	●	●	●	●	●	●	●	●	●
Secondary	Non-racking Main HDPE Float (f)		●				●		●	●		●	●	●	●	●
Secondary	Secondary HDPE Float (g)		●				●		●	●		●	●	●	●	●
Supporting	Connections Pins (h)		●													
Supporting	Bolts/Screws (i)		●	●												
Supporting	Zip ties (j)		●	●												
Supporting	Conduit/Cabling (k)		●	●		●										
Supporting	Chains (l)		●	●												
Supporting	Mooring Lines (m)		●	●				●	●		●					
Supporting	Anchors (n)		●													
Supporting	Perimeter Fencing (o)			●				●	●		●	●	●			●
Supporting	Erosion netting (p)		●	●												



Potential risks and benefits to waterbirds when interacting with components within each element of an FPV structure. All three FPV elements (primary, secondary, and supporting) are comprised of novel floating solar energy components and waterbirds can potentially interact with each of these components.

A circle next to a component indicates either a potential risk or benefit that a waterbird can experience when interacting with that specific component and the lack of a circle indicates no potential risk or benefit for a waterbird.

Potential risks include collisions, degradation of materials, snagging/choking, high thermal temperatures, and electrical shock.

Potential benefits are subdivided into behavioral categories of foraging, maintenance, reproduction, and sociality. Foraging encompasses different feeding behaviors that waterbirds can perform on an FPV and include ambush/stalking, hawking/sallying, and gleaning.

Maintenance behaviors are performed to maintain the physiological stasis of the waterbird and include resting/loafing, perching, drying, and preening or feather cleaning. Reproductive behaviors are performed to produce offspring and include courtship/mating and nesting. Lastly, sociality includes any social interaction between two or more waterbirds. Credit: **a**-**p**, photos by Dr. Rebecca R. Hernandez and Emma Forester.

UCF

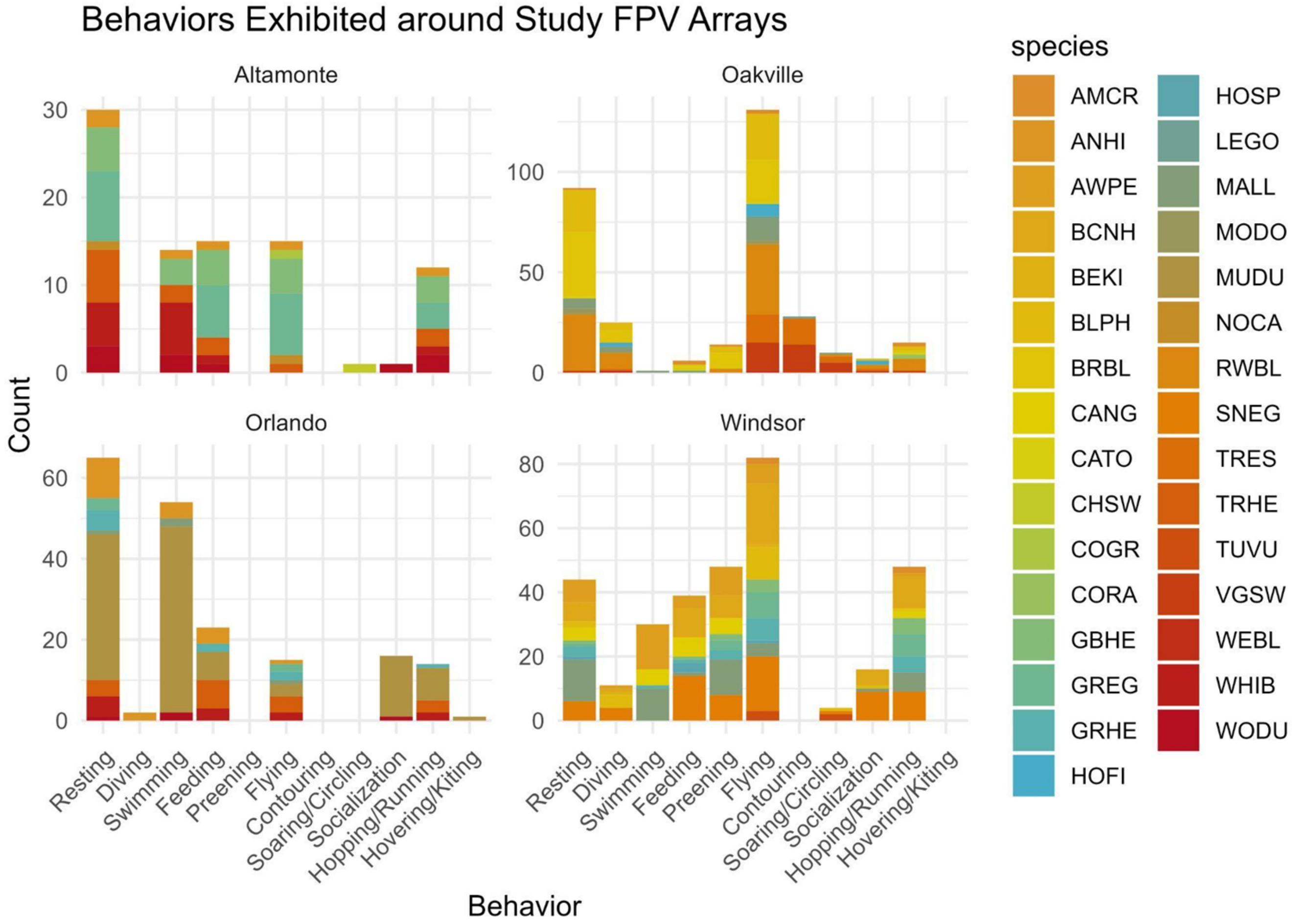
Waterbirds can interact with floating photovoltaics

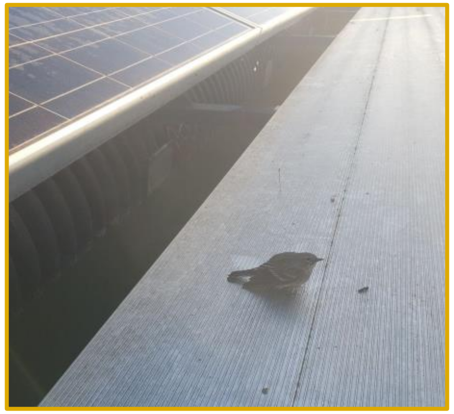
Fig. 4: Waterbirds can interact with floating photovoltaics. A diversity of waterbird species can interact with different FPV elements and components. For instance, **a**, a Great Blue Heron foraging on a non-racking main HDPE float, **b**, a Great Egret resting on a photovoltaic panel, and **c**, an Anhinga drying itself on a racking main HDPE float. Furthermore, waterbirds can be found near FPVs or on supporting features of FPV infrastructure, such as **d**, a Double-crested Cormorant swimming nearby, **e**, a Little Blue Heron foraging on conduit/cabling, and **f**, a Northern Mockingbird resting on a perimeter fence. Yet, the costs and benefits of these FPV-waterbird interactions require testing to help inform potential conservation concessions for waterbirds on and near FPV structures. Credit: **a**-**f**, photos by Dr. Rebecca R. Hernandez.

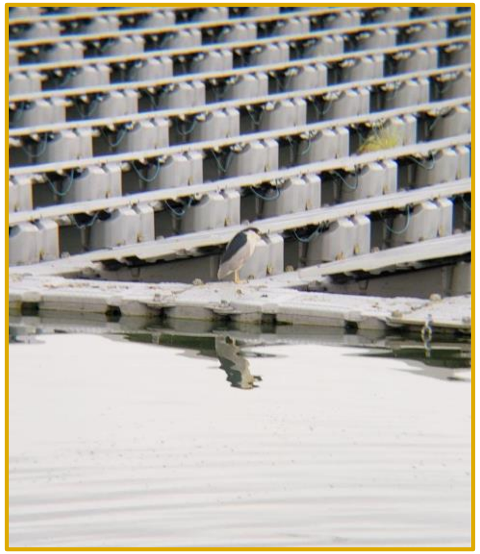
The consideration and anticipation of ecological outcomes owing to FPV expansion can mitigate biodiversity loss as water surfaces become a more prominent, widespread recipient environment for renewable energy infrastructure globally.

More inclination angle less birds?

- Module inclination angle seems to be playing a role.
- More inclination angle less water birds (less soiling) and vice versa.



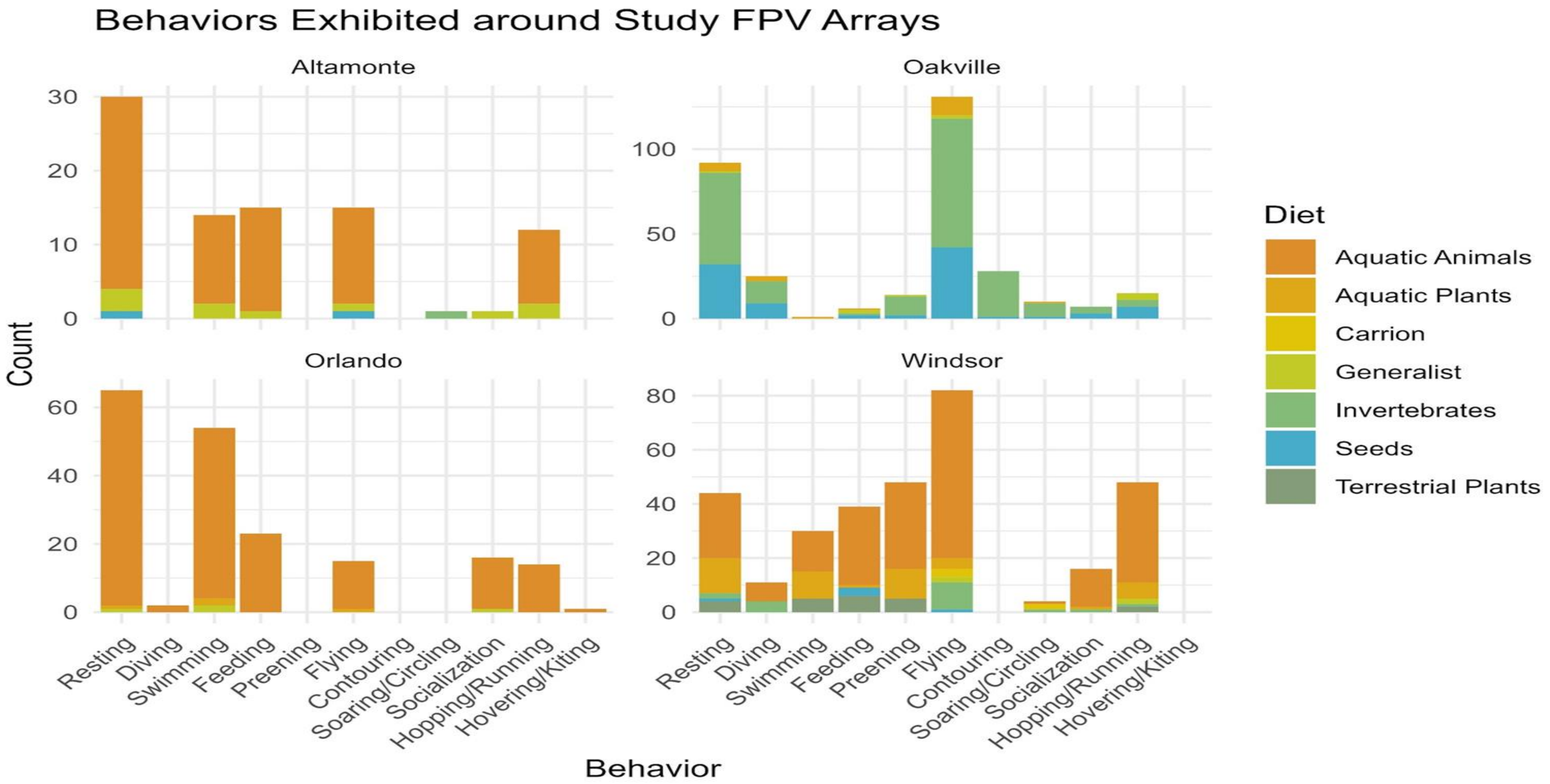




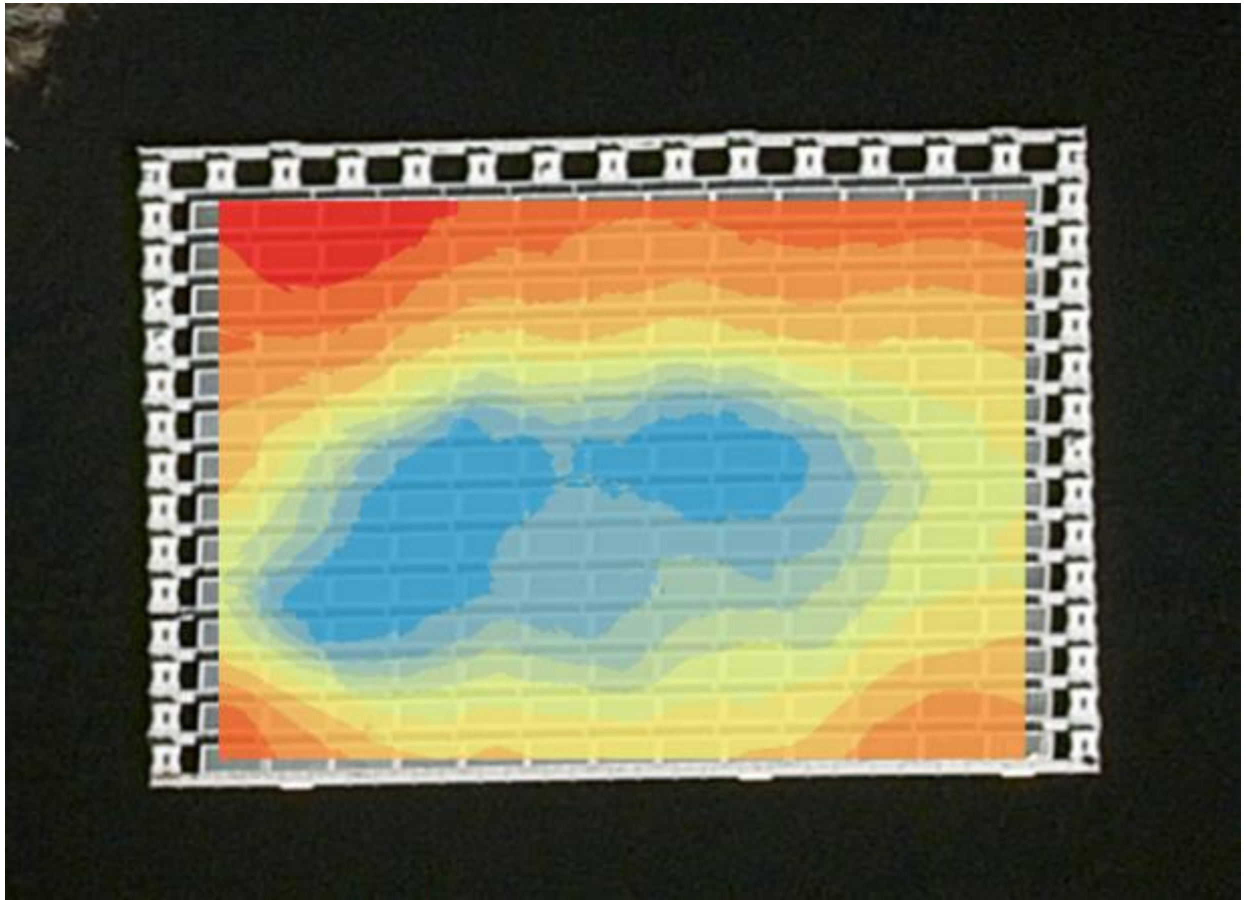
UCF

More inclination angle less birds?

- Module inclination angle seems to be playing a role.
- More inclination angle less water birds (less soiling) and vice versa.



Interpolated soiling map



Example of interpolated soiling surface at 2-FPV (Orlando). Blue represents ‘cold spots,’ or areas predicted to have low levels of soiling, while red represents ‘hot spots,’ or areas predicted to have high levels of soiling.

- Overall, results support observations that soiling accumulates along the perimeter of the FPV array, particularly in the front and back

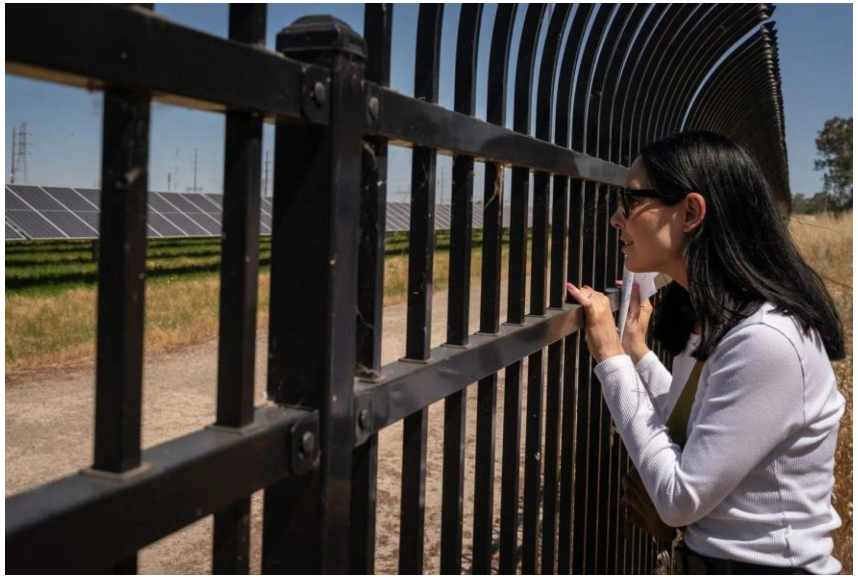
More inclination angle less birds?

- The above images highlight the differences in angle tilt at Windsor (left) and Oakville (right) field sites.

Contacts

Manjunath Matam

manjunath.matam@ucf.edu



Rebecca R. Hernandez

rrhernandez@ucdavis.edu

Emma Forester

ekforester@ucdavis.edu

UCF