

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

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

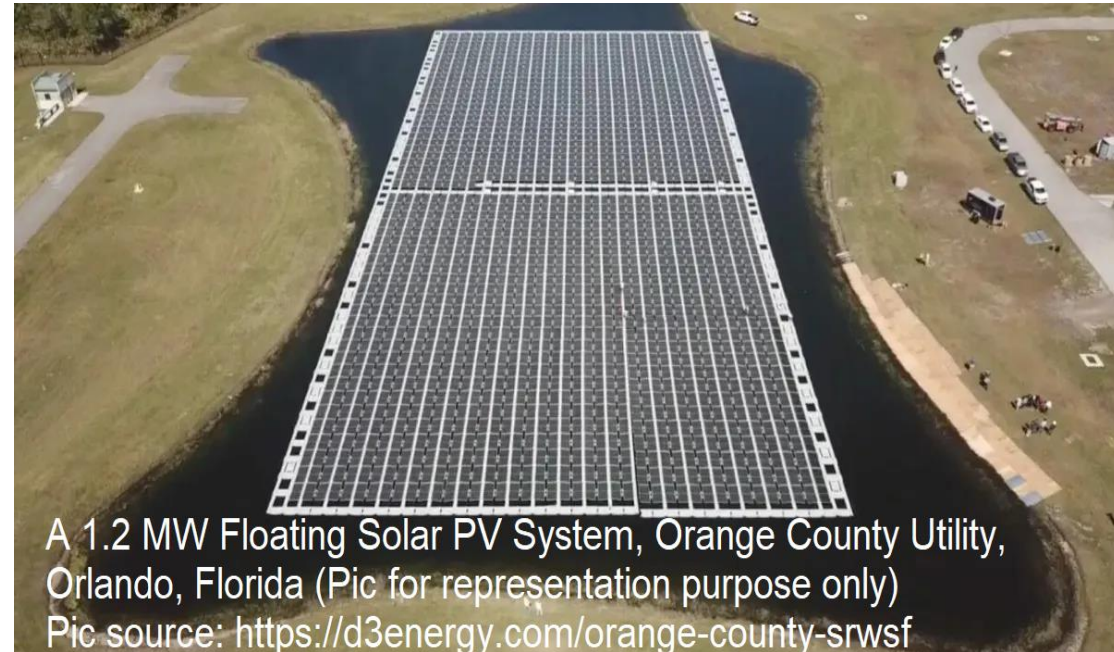
Floating site partners

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.:

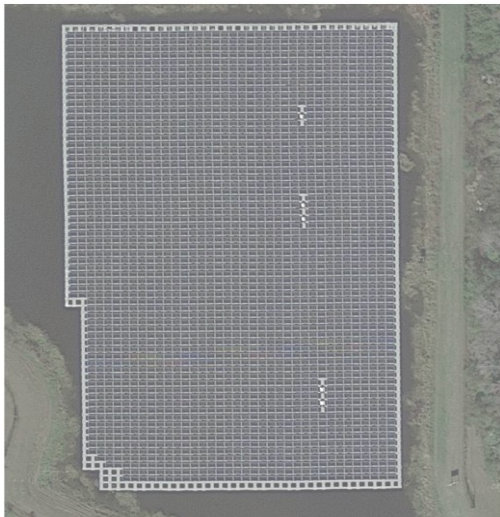
- **Title:** Quantifying and Valuing Fundamental Characteristics and Benefits of Floating Photovoltaic (FPV) Systems
- **Sponsor:** SETO, US Dept. of Energy
- **Funds:** \$1.1 M (20% cost share)
- **PP:** 2020 Mar. – 2024 May
- **Goal:** Study the ecological impacts; collect and analyze FPVs temperature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



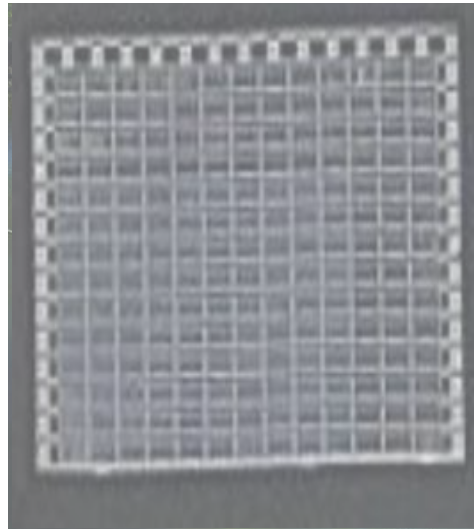
Project sites:

- Studied four floating PV sites

Pic credits: Google image



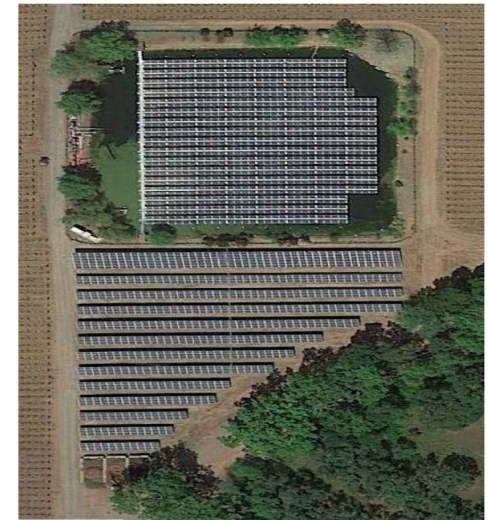
Altamonte Springs, FL
960 kW, Storm Water Pond,
DC/AC 1.16



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%

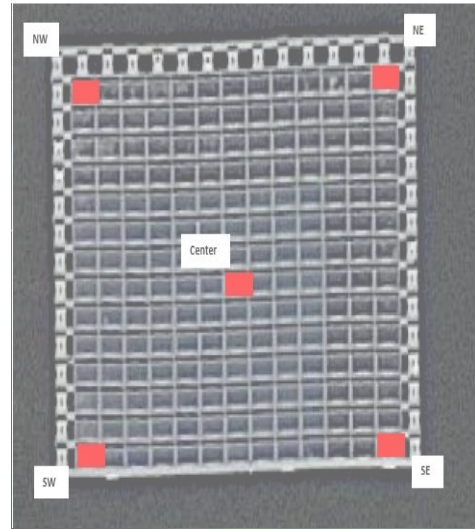
- Common features:

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

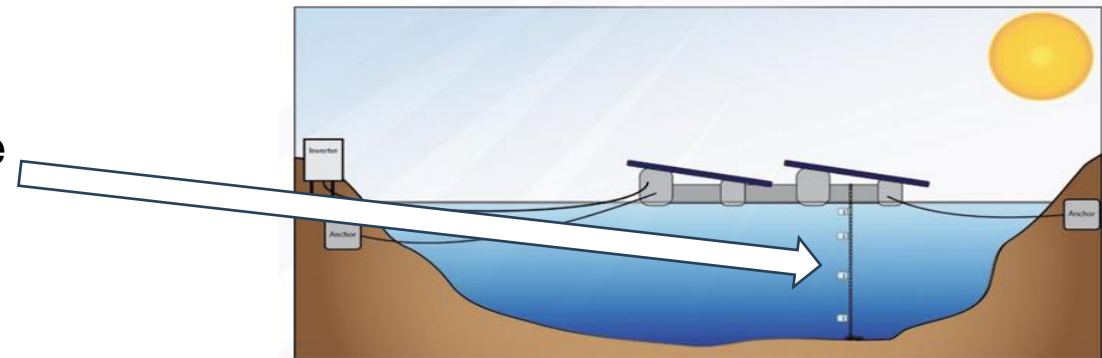
Project sites:

- 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:

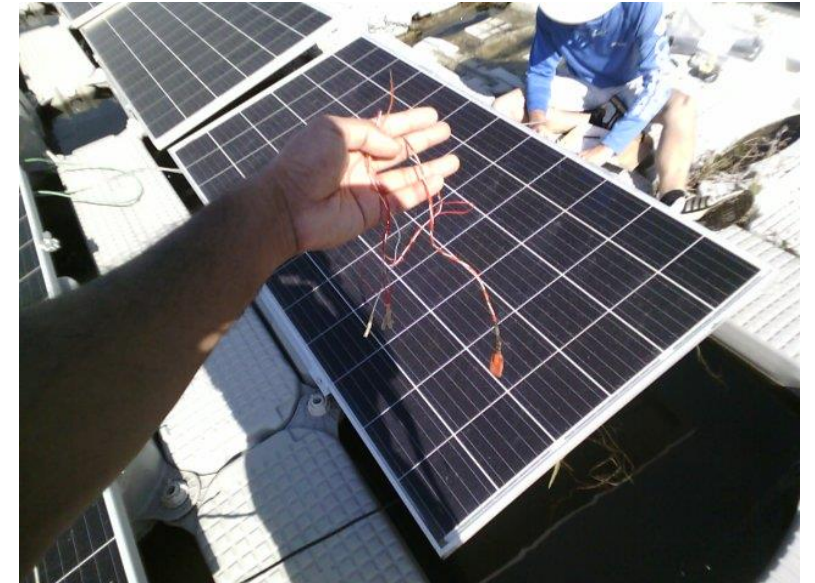
- At sites



You need a boat to float



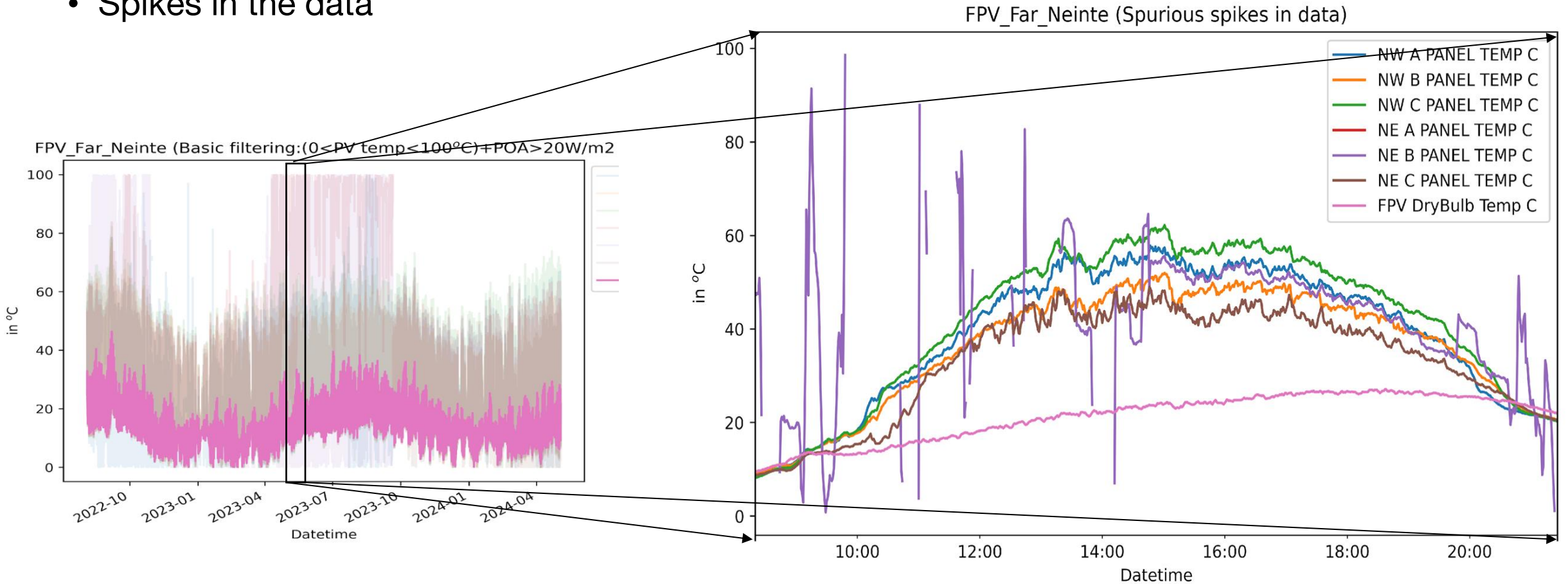
Walking on floats is always challenging



Animals do work with our sensors

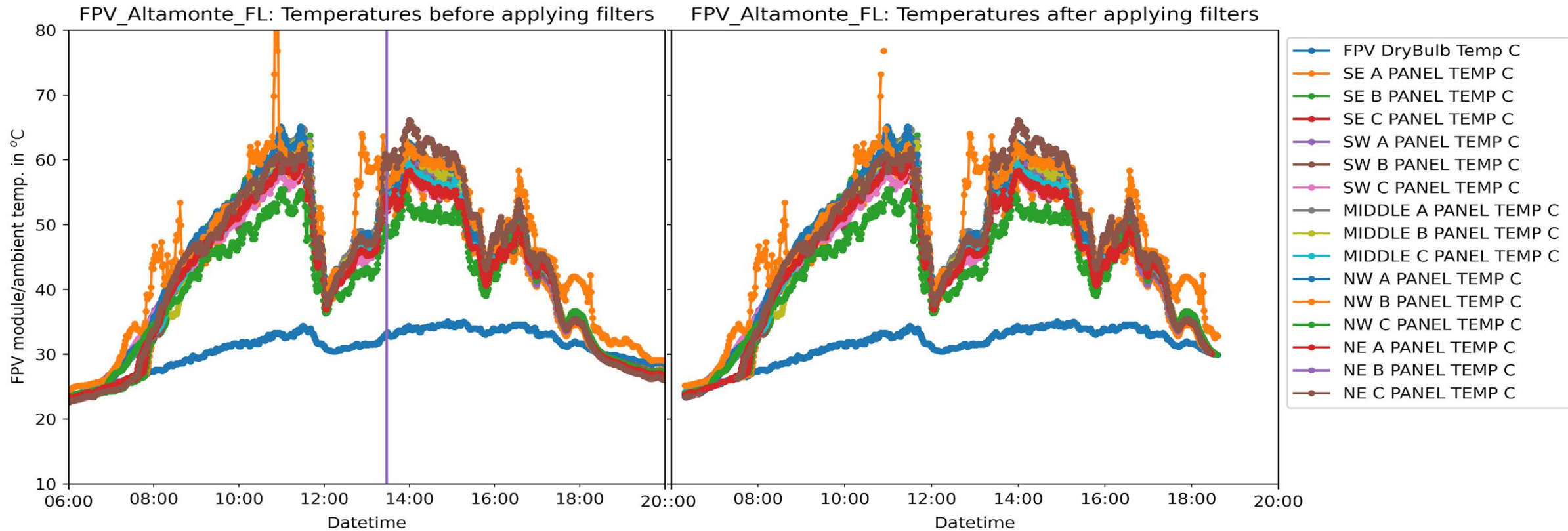
Challenges Overcome:

- Spikes in the data



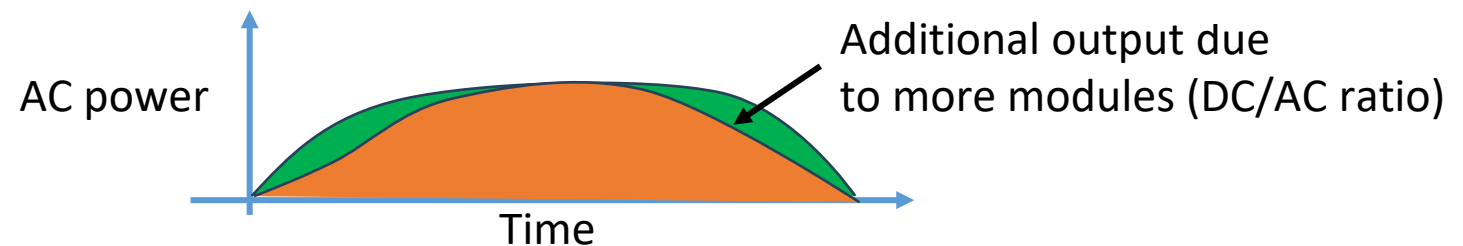
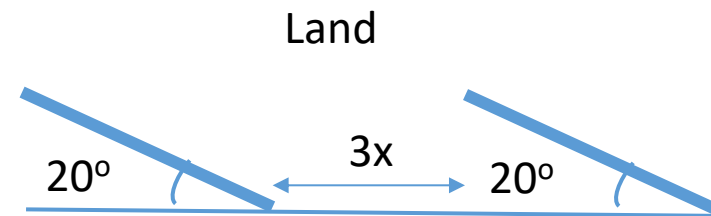
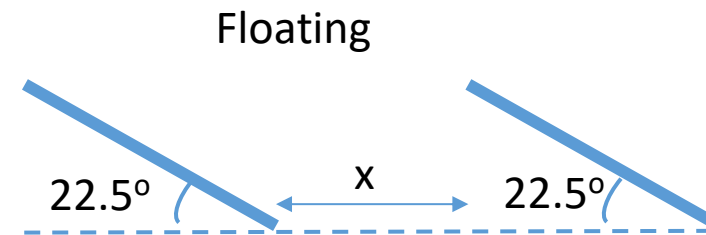
Challenges Overcome:

- Spikes in the data

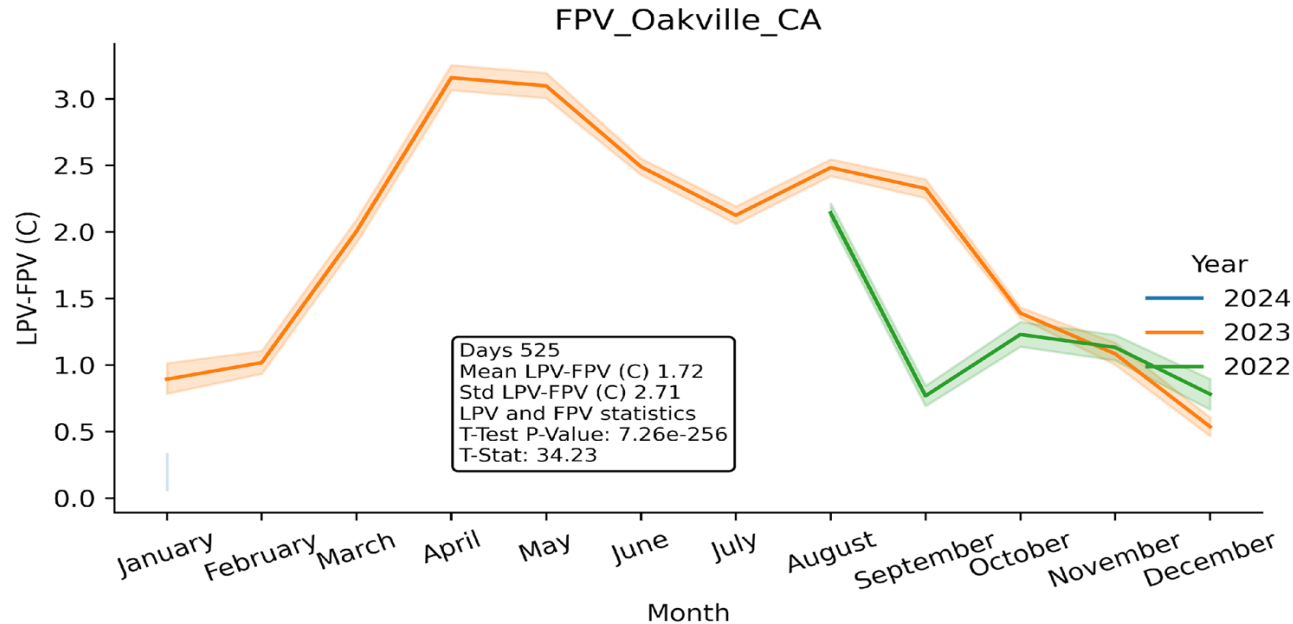


Oakville Site: A True Apples-to-Apples Comparison?

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



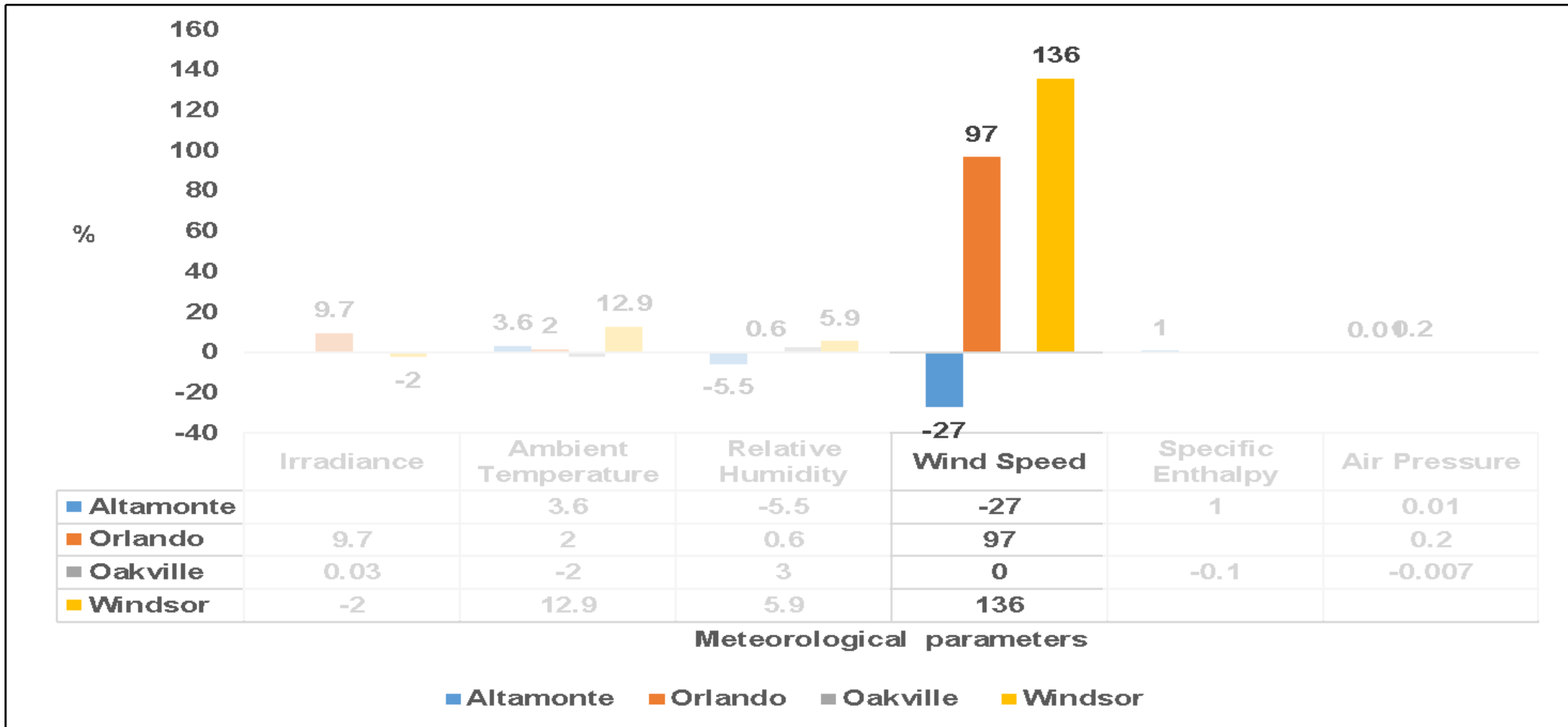
Find-1: Floating modules operate cooler



- 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.

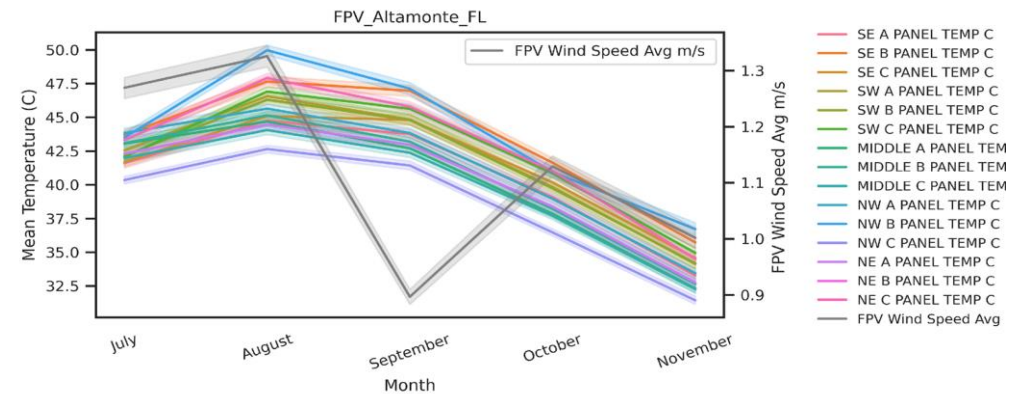
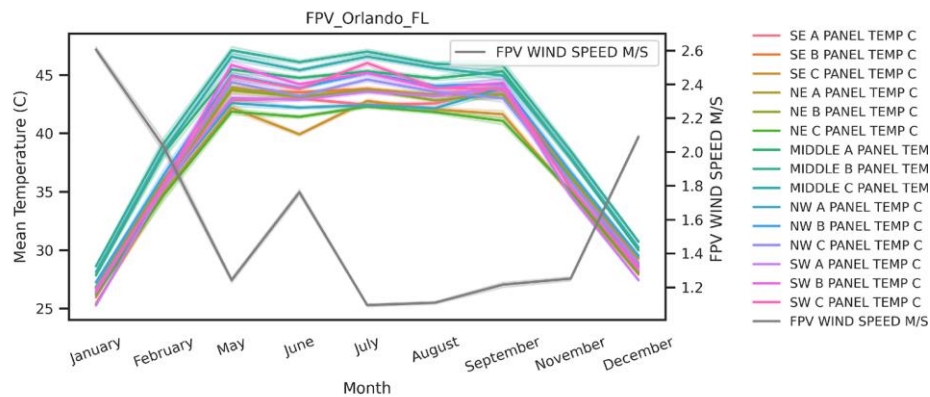
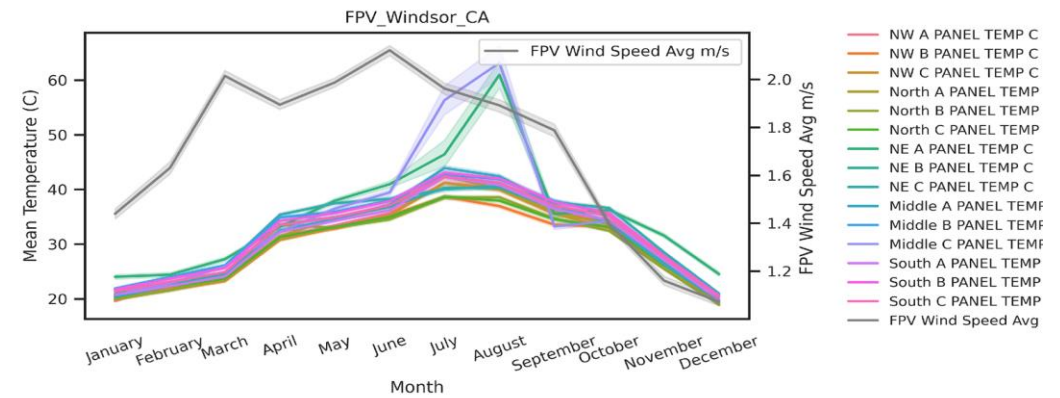
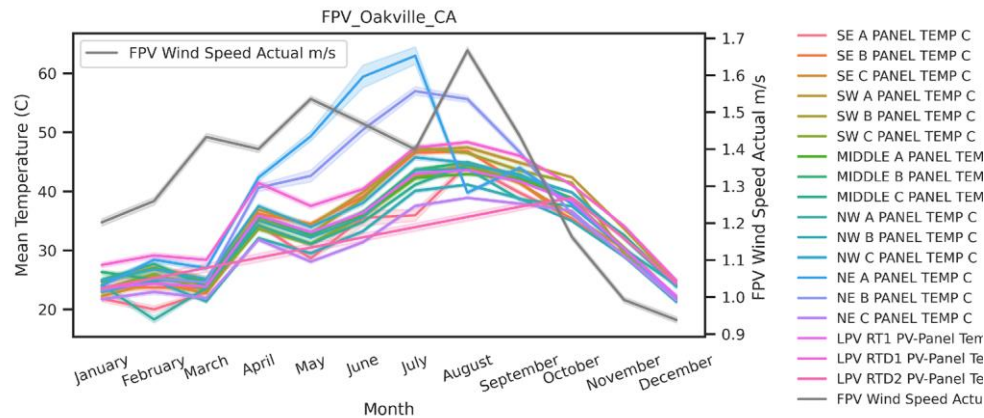
Find-2: More wind on floating arrays

Floating environment compared to nearby adjacent land:



Find-3: Floating modules have high delta

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

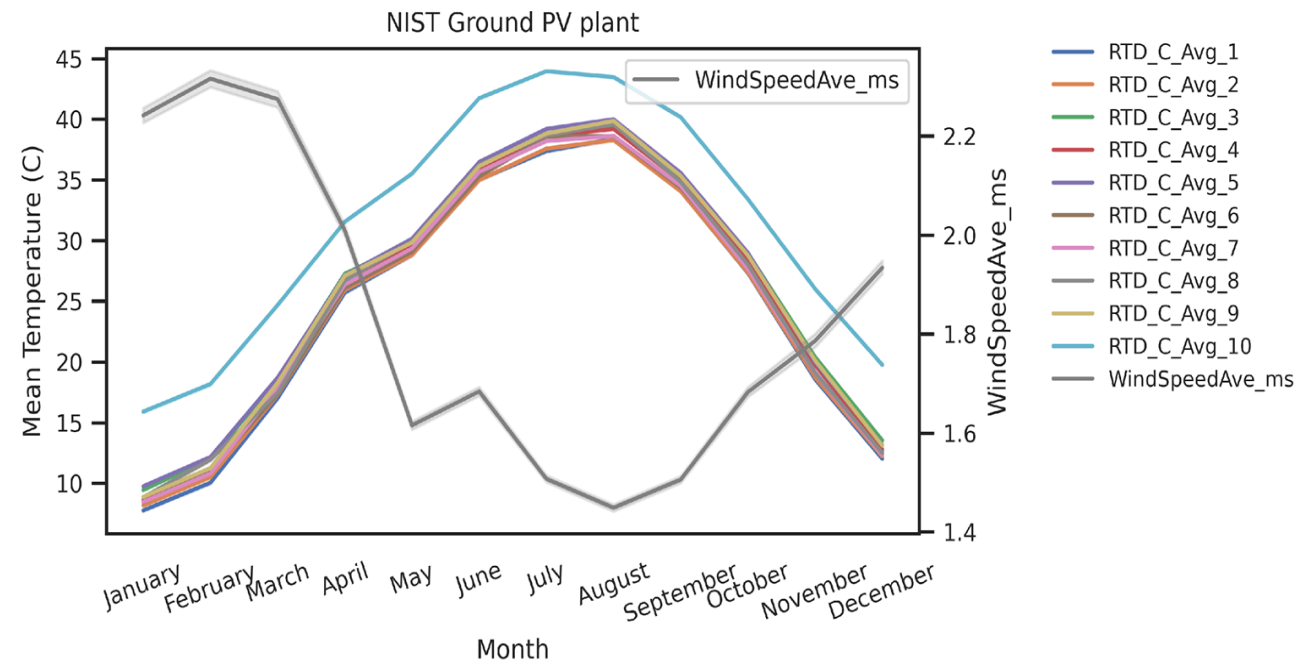


What about Land installed PV modules?

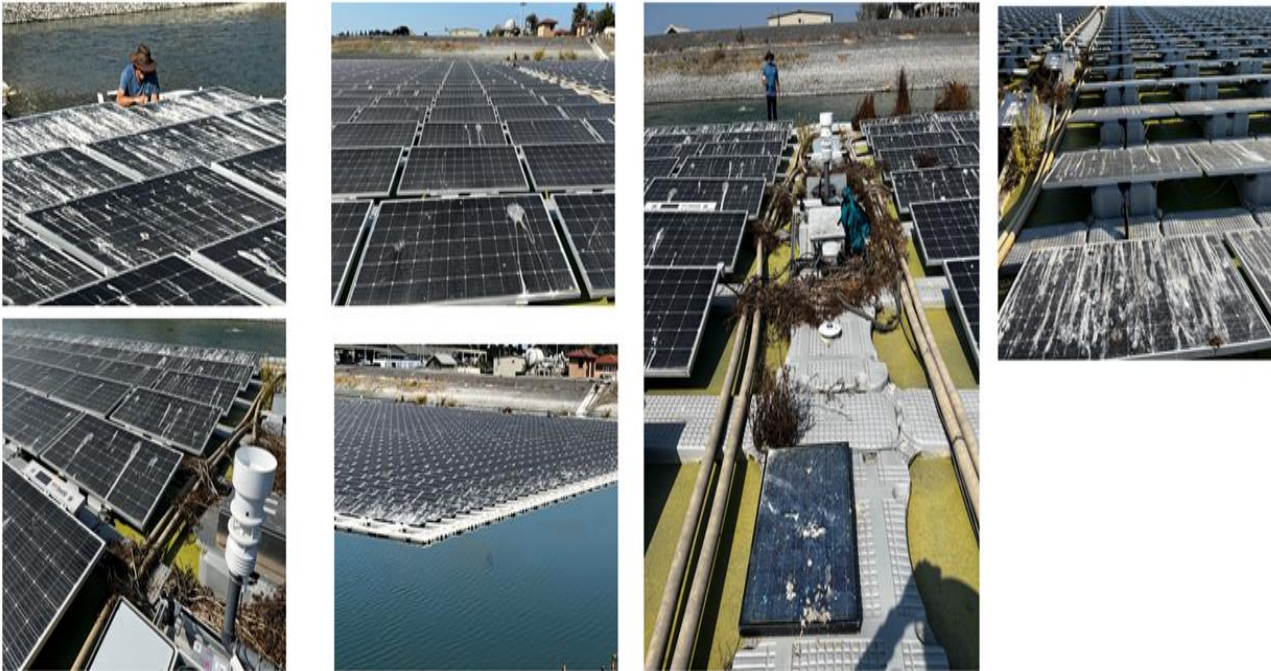
- Same analysis was done for an open-source dataset by NIST.
- 271 kW land installed PV system, 3 years data, 1 min resolution, 9 PV modules temperature.



NIST Ground mounted PV array located in Gaithersburg, MD.



Find-4: Bird droppings could be an issue

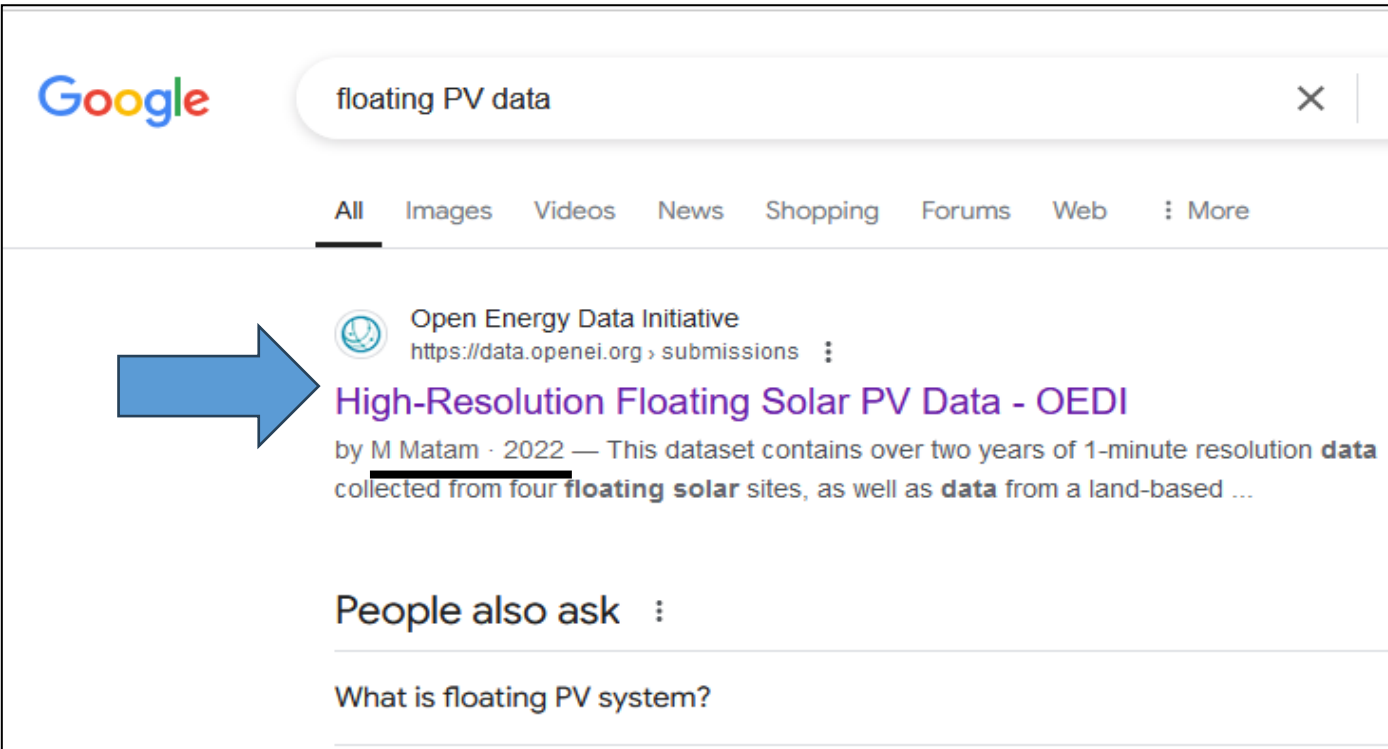


- Windsor site pics from 2023 September visit.
- Site was in operation for 3 years
- More bird droppings on the North/South most modules (?)
 - Does the type of pond and neighboring trees impact this?
 - Does it impact the performance?: *Yes! significant bird droppings reduce the PV output by a high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

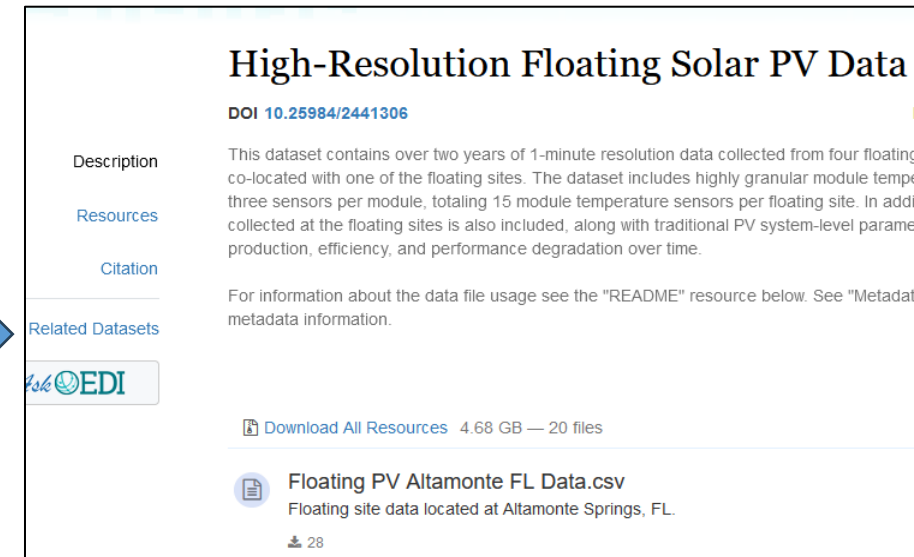
You can access data:

Google it: floating PV data

Landing page



A screenshot of a Google search interface. The search bar contains the text "floating PV data". Below the search bar, there are tabs for "All", "Images", "Videos", "News", "Shopping", "Forums", "Web", and "More". The search results show a link from the "Open Energy Data Initiative" with the URL "https://data.openei.org/submissions". The title of the result is "High-Resolution Floating Solar PV Data - OEDI" in purple text. Below the title, it says "by M Matam · 2022 — This dataset contains over two years of 1-minute resolution data collected from four floating solar sites, as well as data from a land-based ...". A blue arrow points from the left towards the search result. Below the search results, there is a section titled "People also ask" with a question: "What is floating PV system?".



A screenshot of the landing page for the dataset "High-Resolution Floating Solar PV Data". The page has a white background with a dark blue header. The title "High-Resolution Floating Solar PV Data" is in a large, bold, dark blue font. Below the title, there is a DOI link: "DOI 10.25984/2441306". The page is divided into sections: "Description", "Resources", "Citation", and "Related Datasets". The "Description" section contains text about the dataset's content. The "Resources" section includes a link to "Download All Resources" with details "4.68 GB — 20 files". Below this, there is a list of resources, including "Floating PV Altamonte FL Data.csv" with a description "Floating site data located at Altamonte Springs, FL." and a download icon. A blue arrow points from the search result on the left towards this landing page.

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)

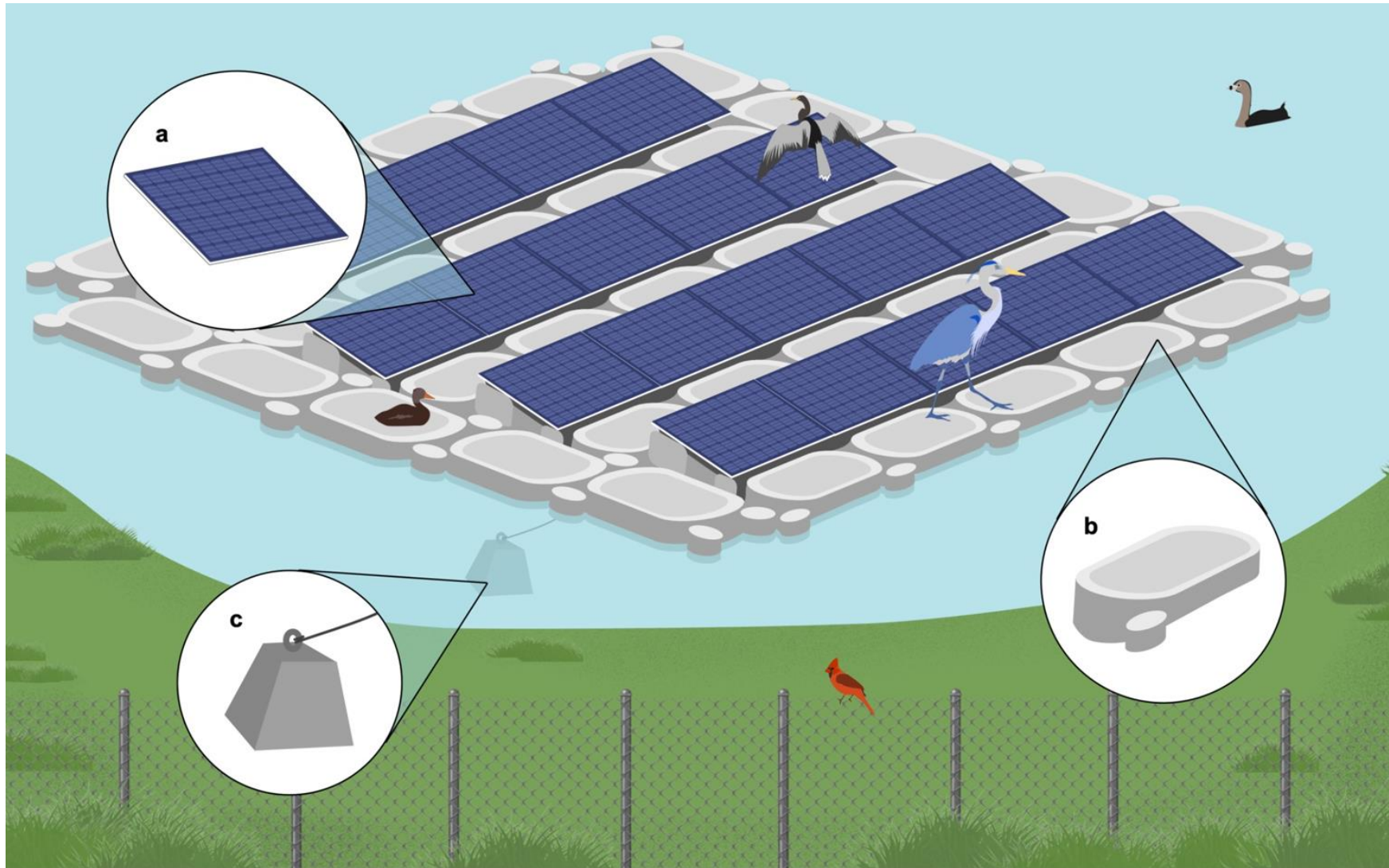


Fig. 1: Floating photovoltaic structures (FPVs) have three distinct elements.

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.

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.

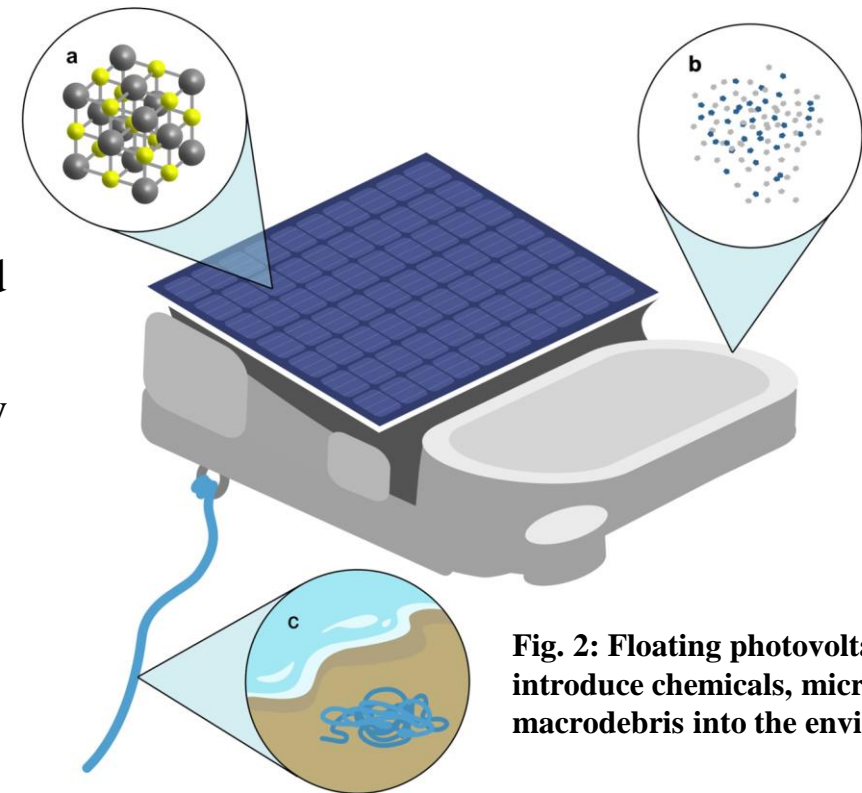


Fig. 2: Floating photovoltaics may introduce chemicals, microplastics, and macrodebris into the environment.

Novel Floating Solar Energy Components	Potential Risk	Potential Benefits			
		Foraging	Maintenance	Reproduction	Sociality
Primary					
PV Panel (a)	● ● ● ●	● ● ●	● ● ● ●	● ●	●
PV Mounted Racking Main HDPE Float (b)	●	● ● ●	● ● ● ●	● ●	●
Non-racking Main HDPE Float (c)	● ● ● ●	● ● ●	● ● ● ●	● ●	●
Combiner Box (d)	●	● ● ●	● ● ●	● ●	●
Secondary					
Racking Main HDPE Float (e)	●	● ● ●	● ● ● ●	● ●	●
Non-racking Main HDPE Float (f)	● ● ● ●	● ● ●	● ● ● ●	● ●	●
Secondary HDPE Float (g)	●	● ● ●	● ● ●	● ●	●
Supporting					
Connections Pins (h)	●				
Bolts/Screws (i)	● ● ●				
Zip ties (j)	● ● ● ●				
Conduit/Cabling (k)	● ● ● ● ●				
Chains (l)	● ● ● ●				
Mooring Lines (m)	● ● ● ●	● ●	●		
Anchors (n)	● ● ● ●	● ●	● ● ●		●
Perimeter Fencing (o)	● ● ● ●				
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.

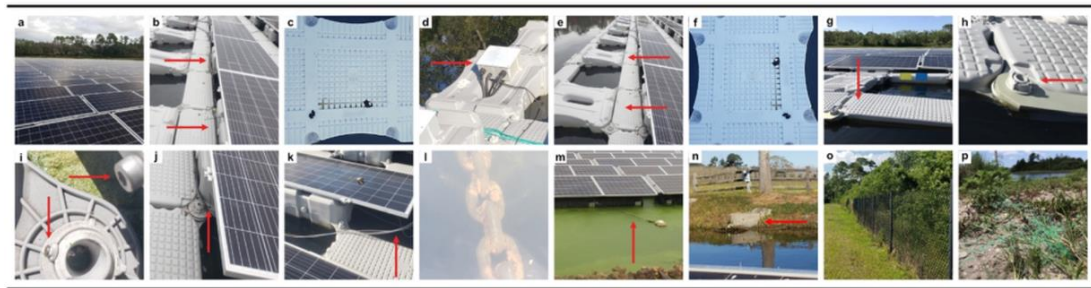


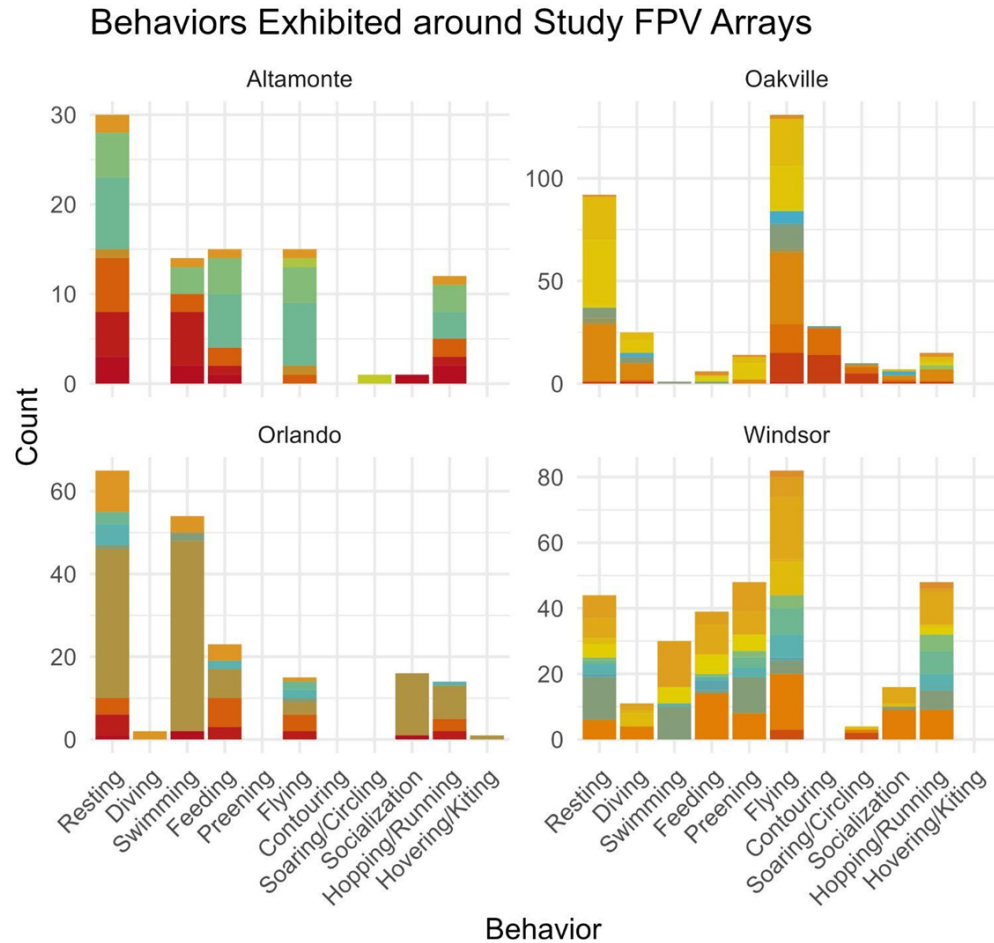


Fig. 4: Waterbirds can interact with floating photovoltaics. A diversity of waterbird species can interact with different FPV elements and components. For instance, **a**, a Great Blue Heron foraging on a non-racking main HDPE float, **b**, a Great Egret resting on a photovoltaic panel, and **c**, an 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.

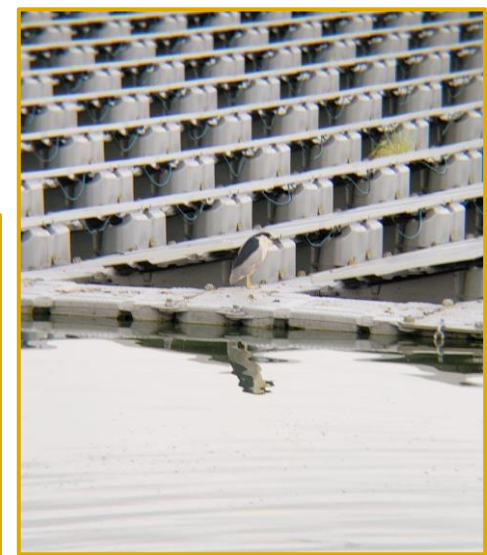
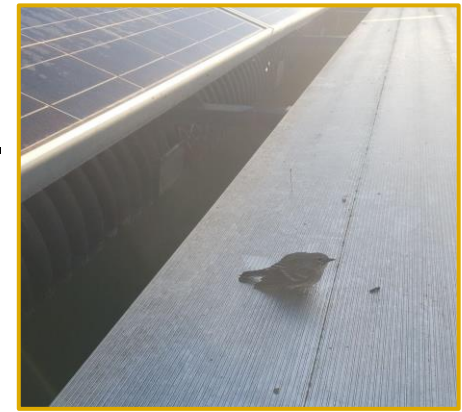
More inclination angle less birds?

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



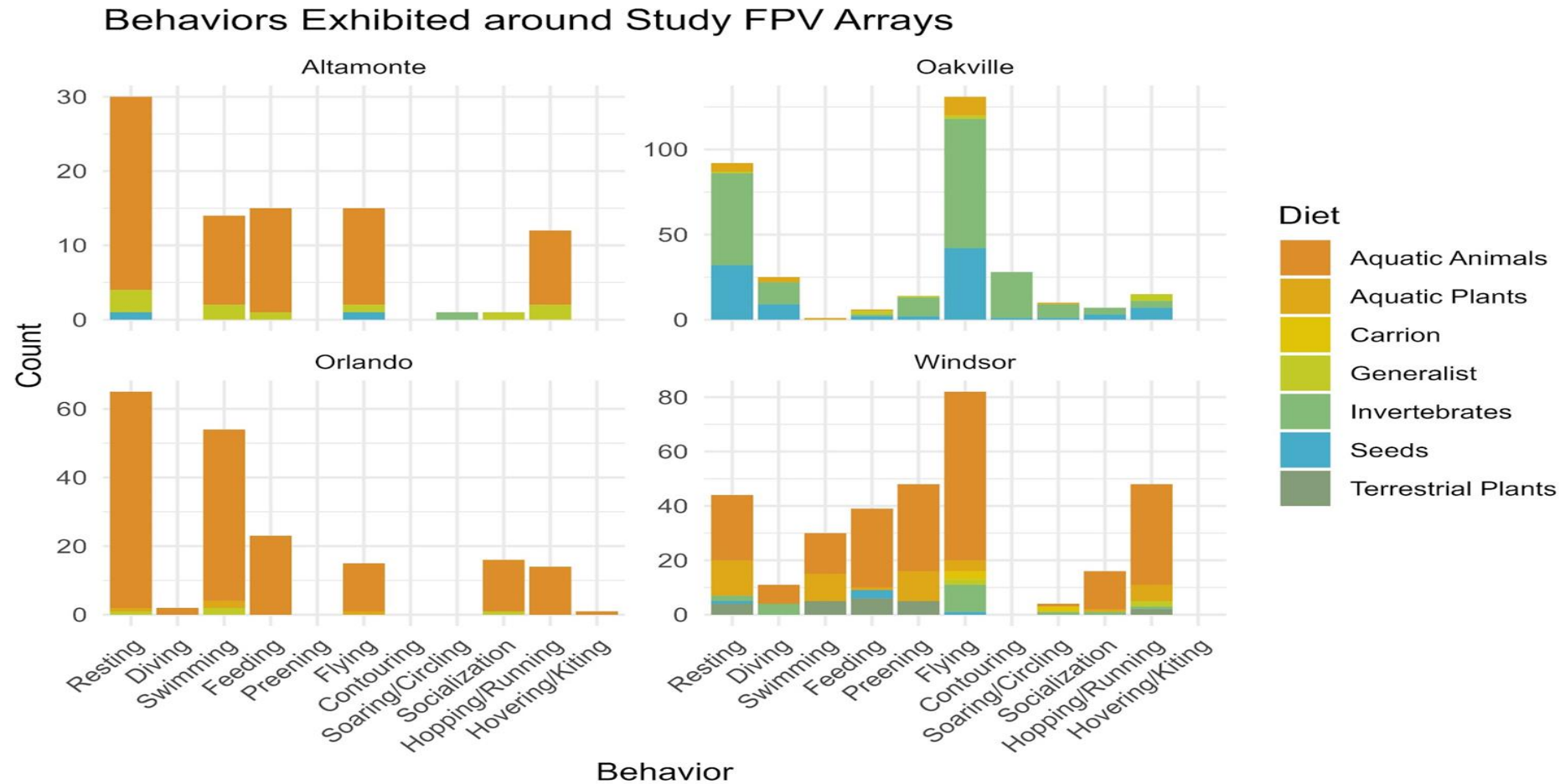
species

AMCR	HOSP
ANHI	LEGO
AWPE	MALL
BCNH	MODO
BEKI	MUDU
BLPH	NOCA
BRBL	RWBL
CANG	SNEG
CATO	TRES
CHSW	TRHE
COGR	TUVU
CORA	VGSW
GBHE	WEBL
GREG	WHIB
GRHE	WODU
HOFI	

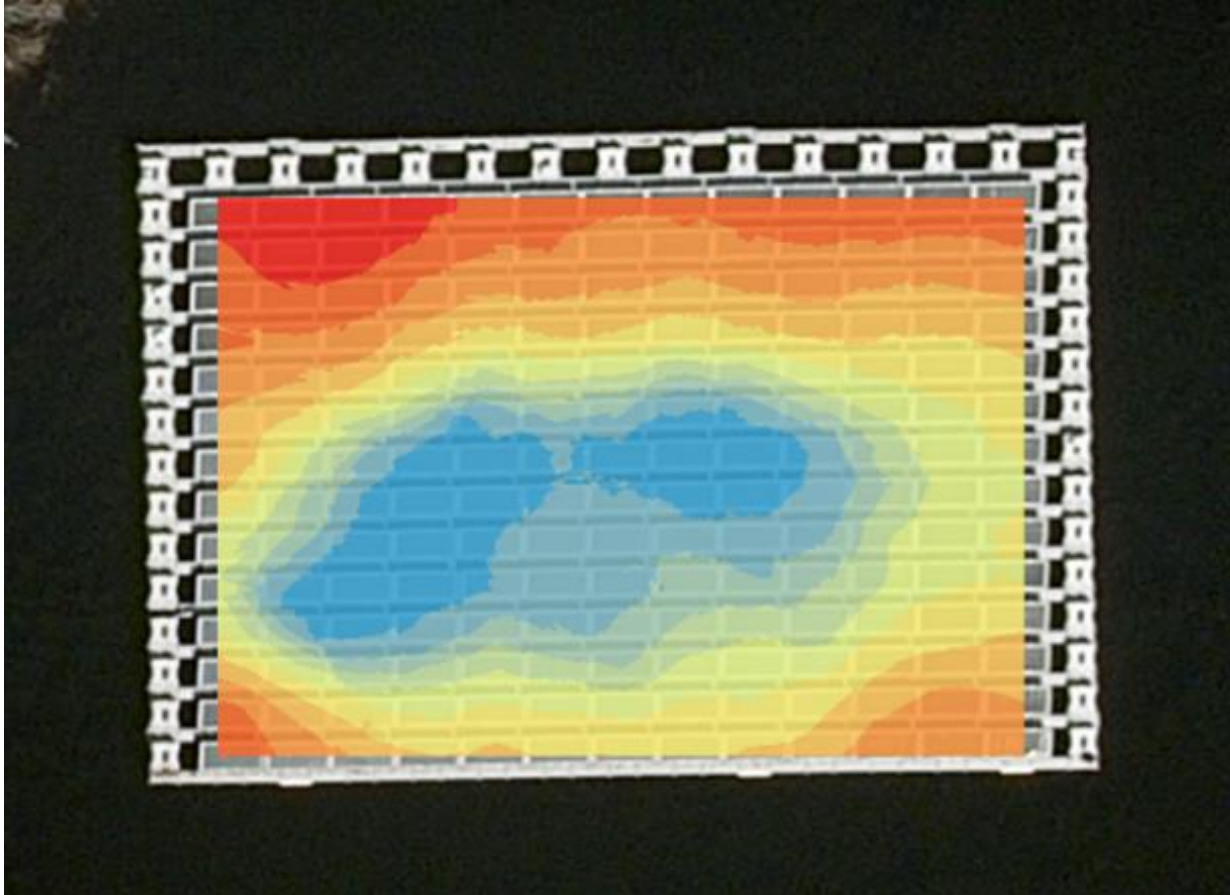


More inclination angle less birds?

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



Interpolated soiling map



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

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.

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