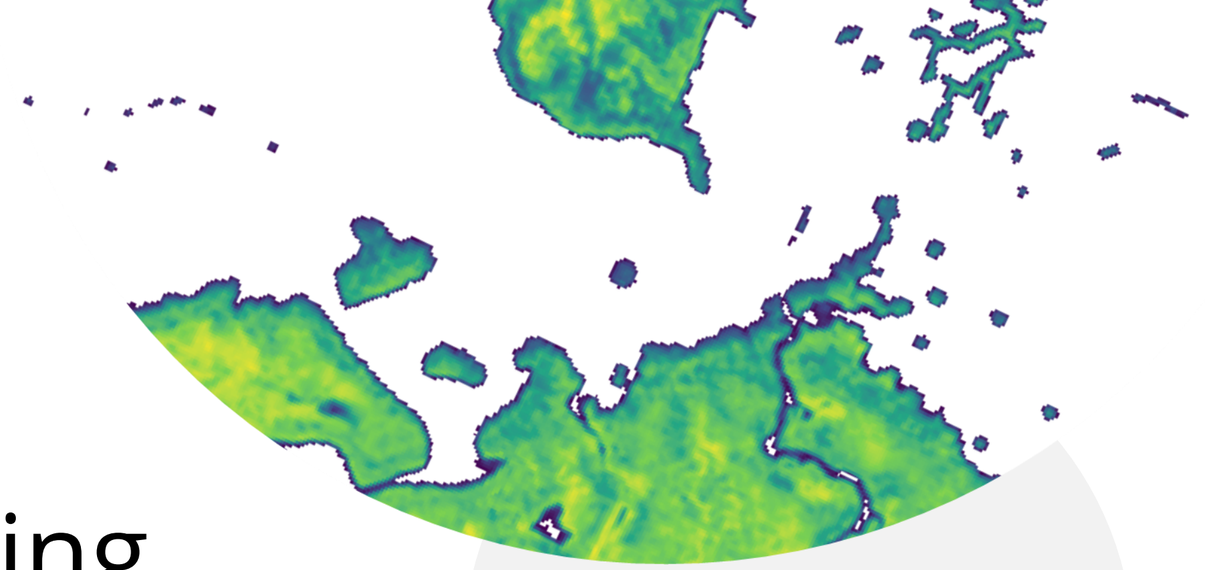
American Anthropological Association

November 21, 2024

Tampa, FL



Using Machine Learning to Document, Preserve, and Protect **Southwest Florida's Archaeological Legacy**

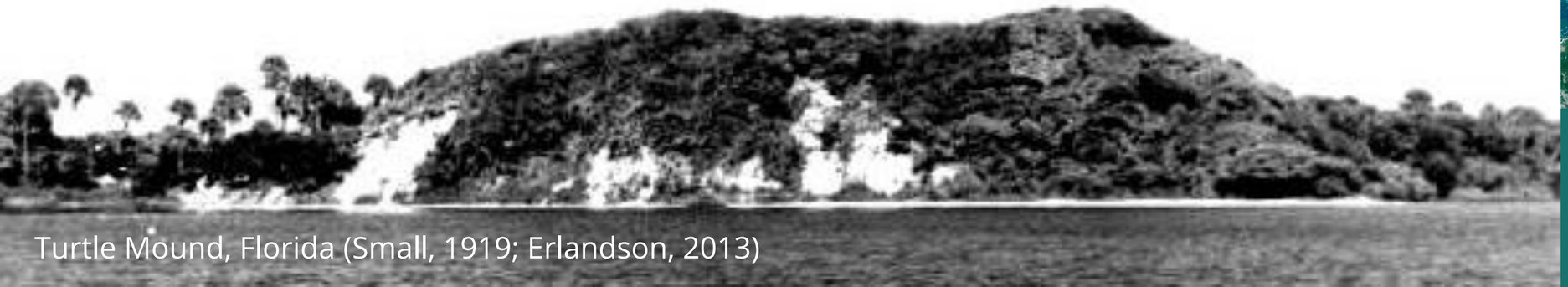
Olivia Zhang
Department of Geography
University of Florida

Dr. Nicolas Gauthier
AI for Bio/Cultural Diversity Lab
Florida Museum of Natural History

Dr. Michelle J. LeFebvre
South Florida Archaeology
Florida Museum of Natural History

WHAT ARE SHELL MOUNDS?

- Large earthworks of shells (clams, oysters, whelks), and other objects; found globally and prevalent along Florida's Gulf Coast
- Created by generations of Indigenous Peoples
- Vulnerable to hurricanes and other disaster events
- Currently, we do not know the locations of all shell mounds in Florida, limiting historic preservation and disaster response efforts



Turtle Mound, Florida (Small, 1919; Erlandson, 2013)

Shell Middens at Fort George

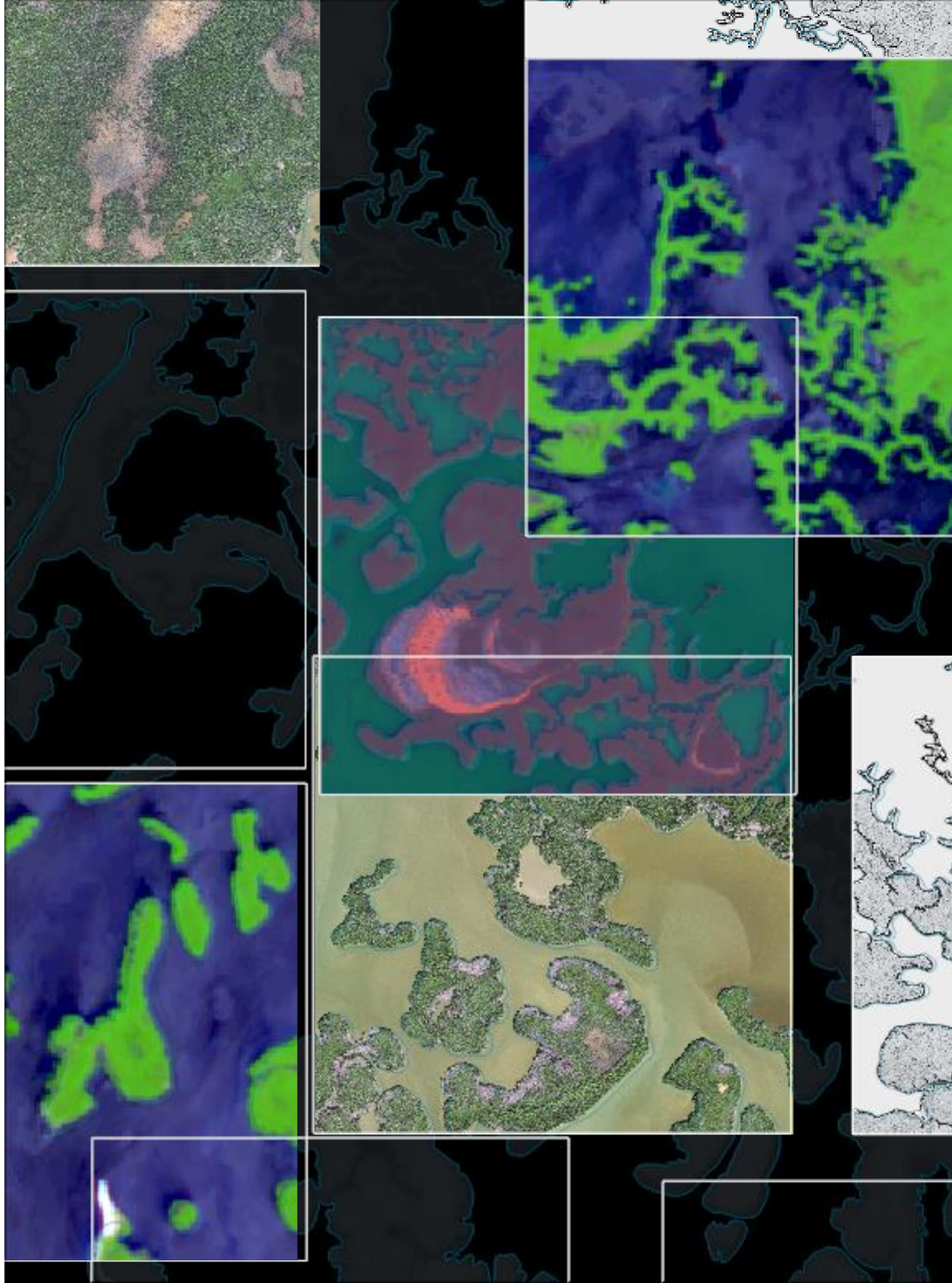
Florida State Parks

Hurricane Ian (2022)

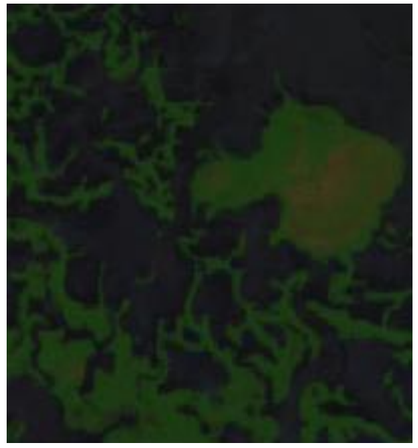
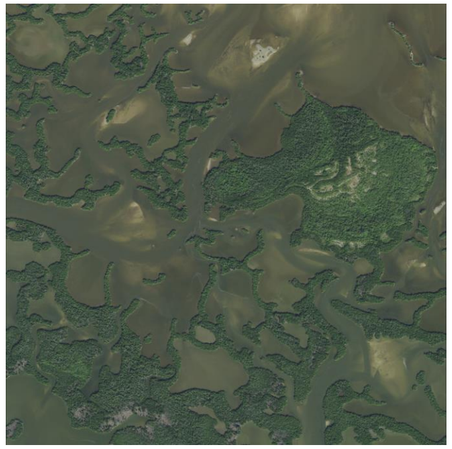
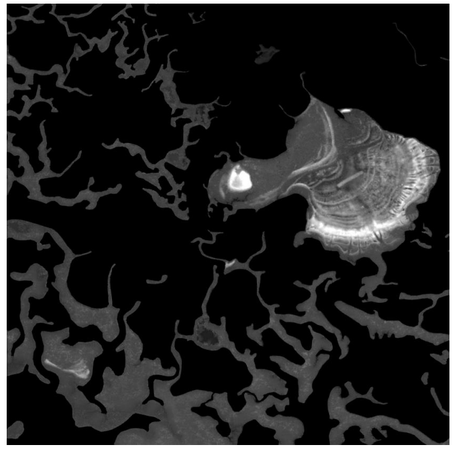
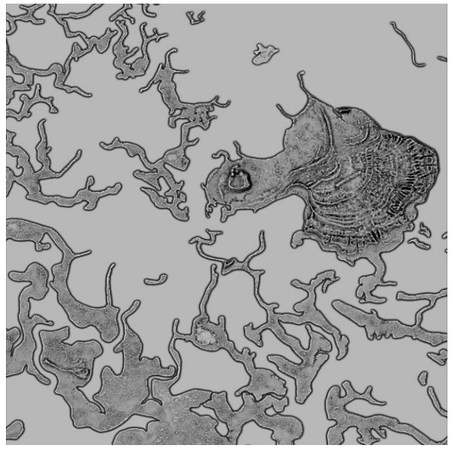
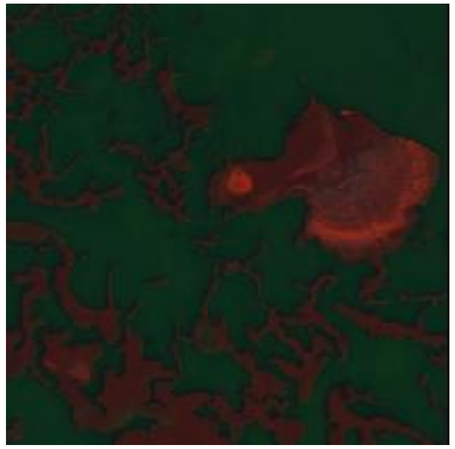
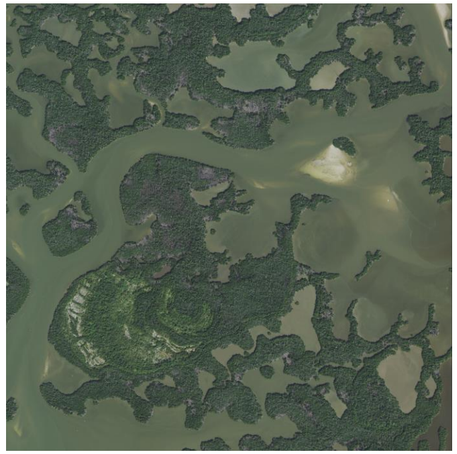
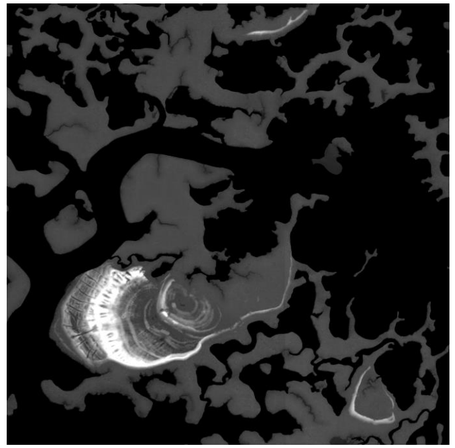
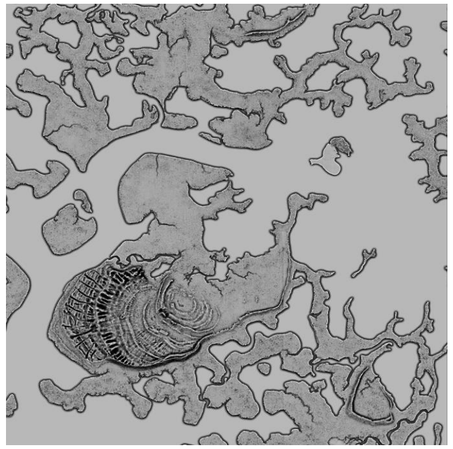
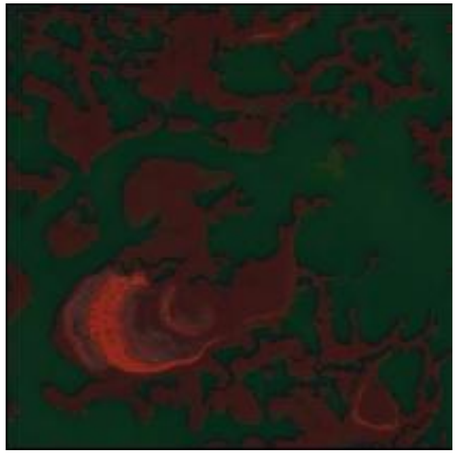
NASA Earth Observatory image by Joshua Stevens

WHAT MAKES SHELL MOUNDS STAND OUT?

- Elevated above the ground—can be seen with Lidar-derived digital elevation models
- Supports unique plant communities (e.g., endemic species)—can be seen from satellite and aerial imagery
- How can we apply AI to identify these characteristics and patterns of shell mounds?

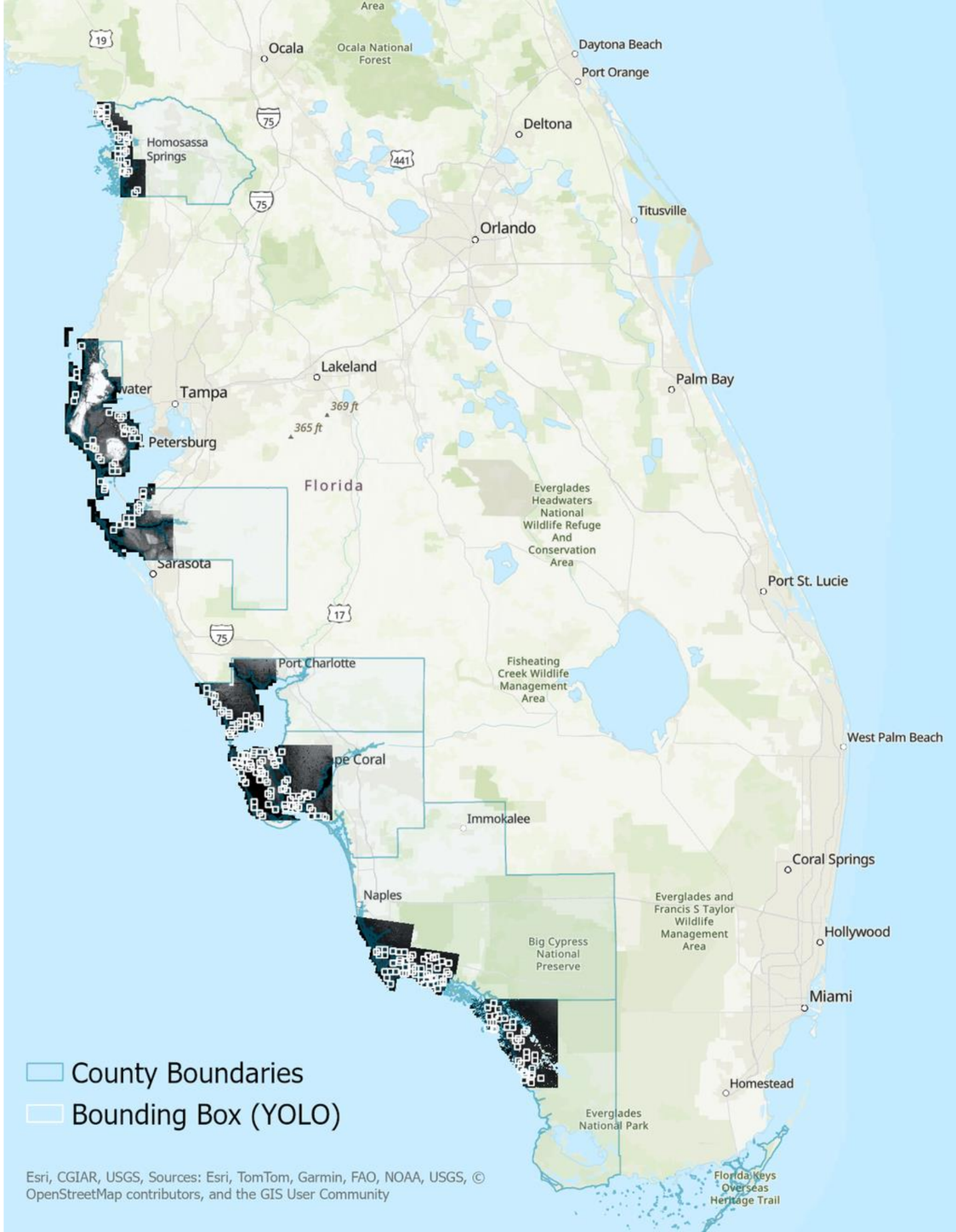


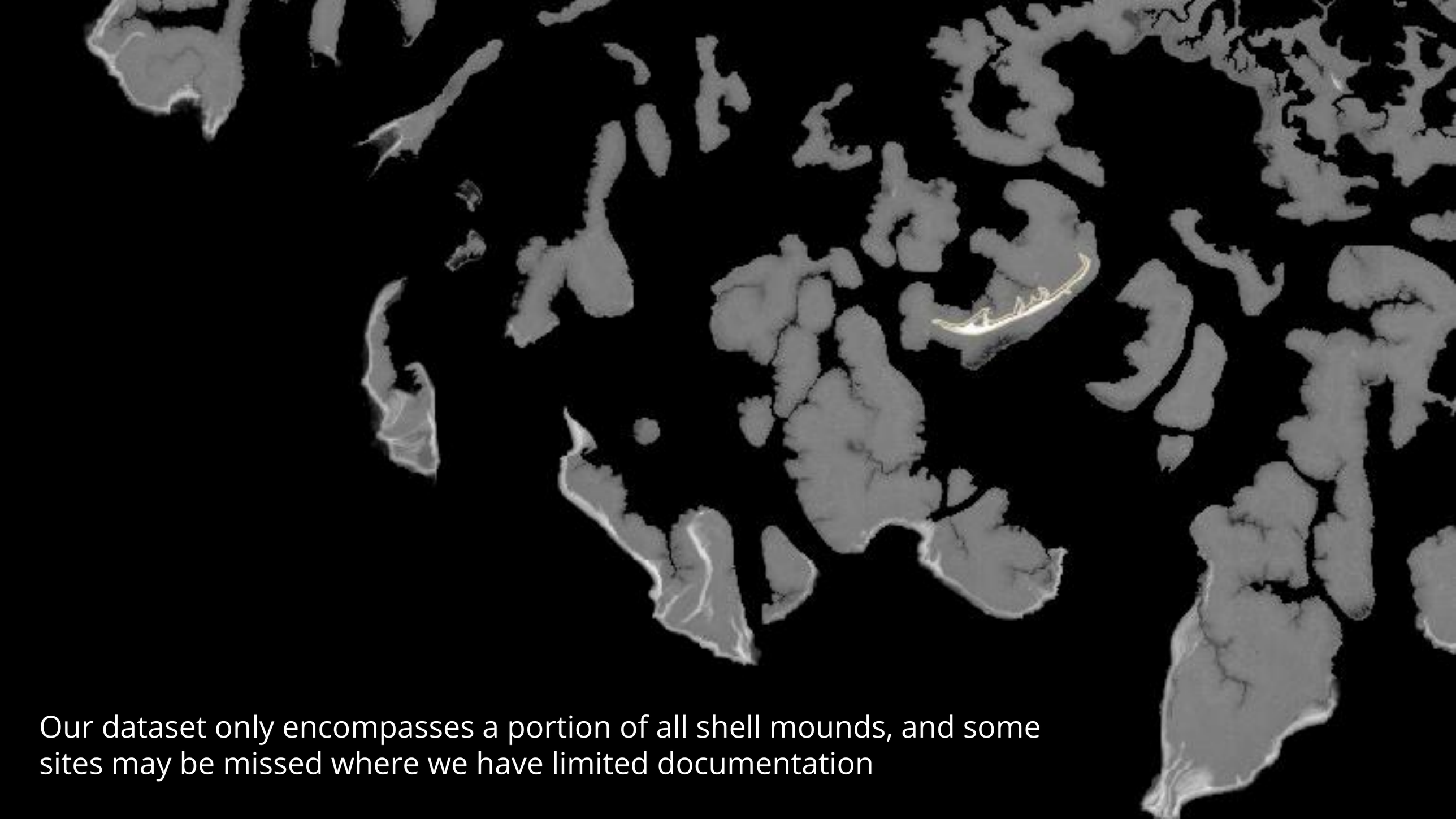
VIEWS OF SHELL MOUNDS

	Satellite Image Sentinel-2 (Bands 11, 8, 2)	**Aerial Image** National Agriculture Imagery Program	**LiDAR-derived DEM** USGS, FDEM, NOAA	**Visualization for Archaeological Topography** Relief Visualization Toolbox	**Satellite Image + DEM** Principal Components Analysis
Fakahatchee Key					
Dismal Key					

DATA EXTENT

- Satellite, aerial, and elevation data from seven counties:
    - Citrus, Pinellas, Manatee, Charlotte, Lee, Collier, Monroe
- Shell mound locations from Florida Master Site File from the Florida Division of Historical Resources, manually corrected based on Lidar DEM data
    - ~200 shell mounds in total





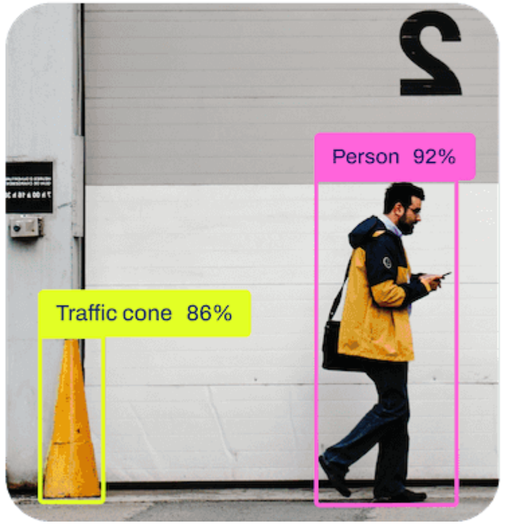
Our dataset only encompasses a portion of all shell mounds, and some sites may be missed where we have limited documentation

OBJECT DETECTION & SEGMENTATION WITH YOLOv8

You Only Look Once (YOLO) version 8, developed by Ultralytics

- Can **detect** objects in images
- And **trace** their specific shape
- Already trained on Microsoft Common Objects in Context (COCO) dataset (~200K labeled images with 80 different objects)
    - Does not include shell mounds
- We fine-tune this model with ~100 epochs to be able to recognize shell mounds, while keeping the knowledge learned from the default model

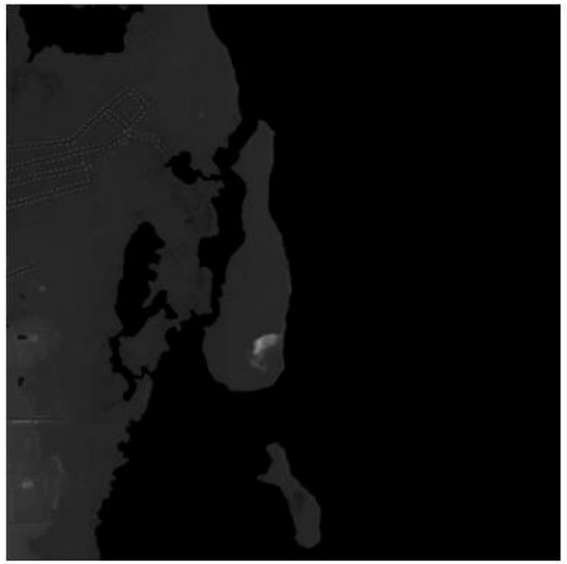
Detect

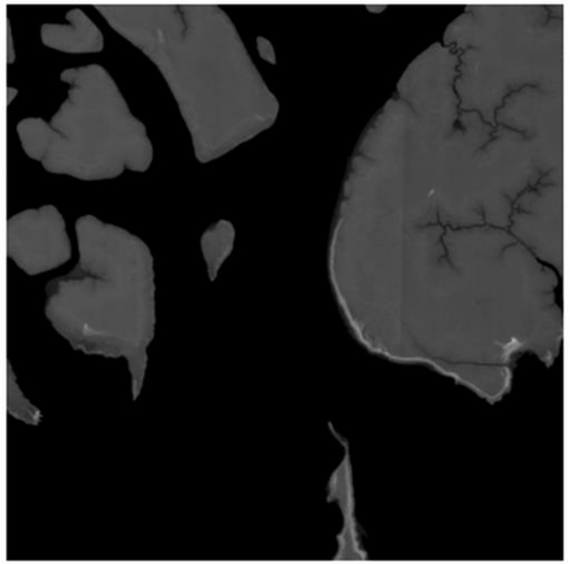


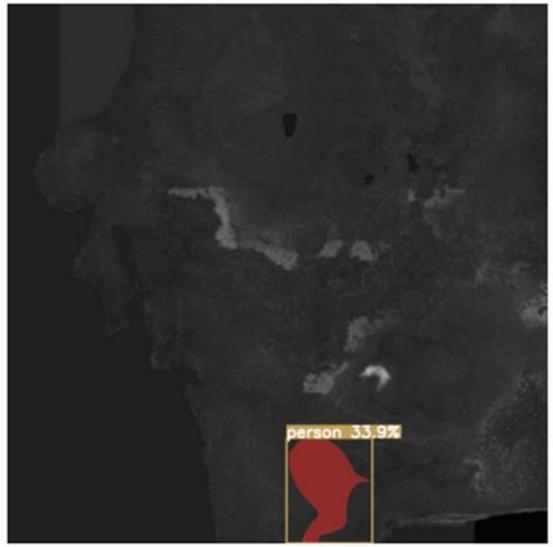
Segment

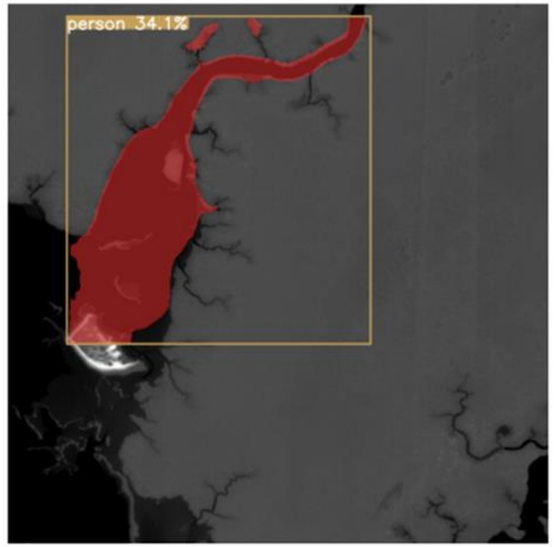
WHY FINE TUNE?

The YOLOv8 model on its own sometimes doesn’t predict anything . . .





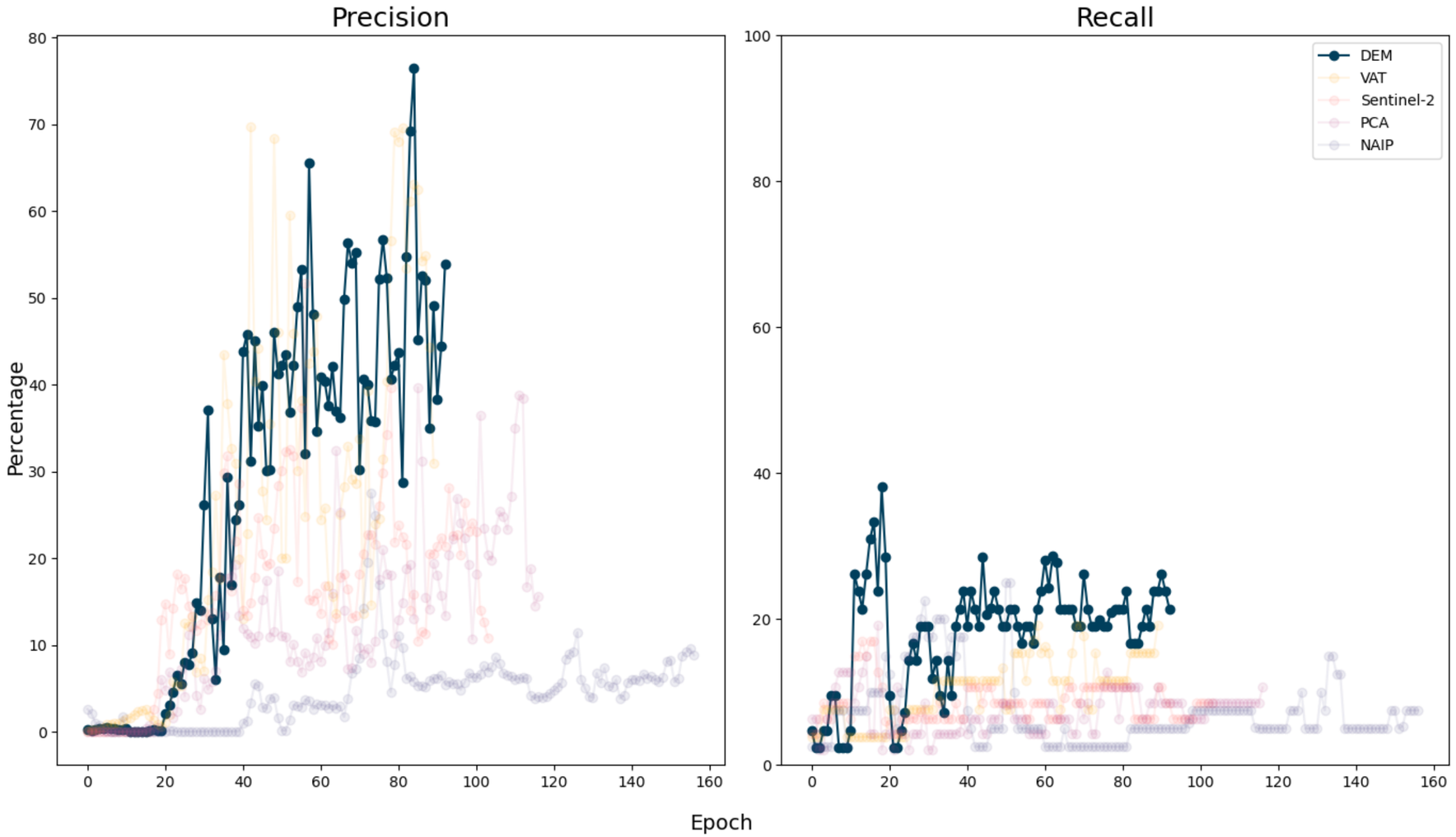


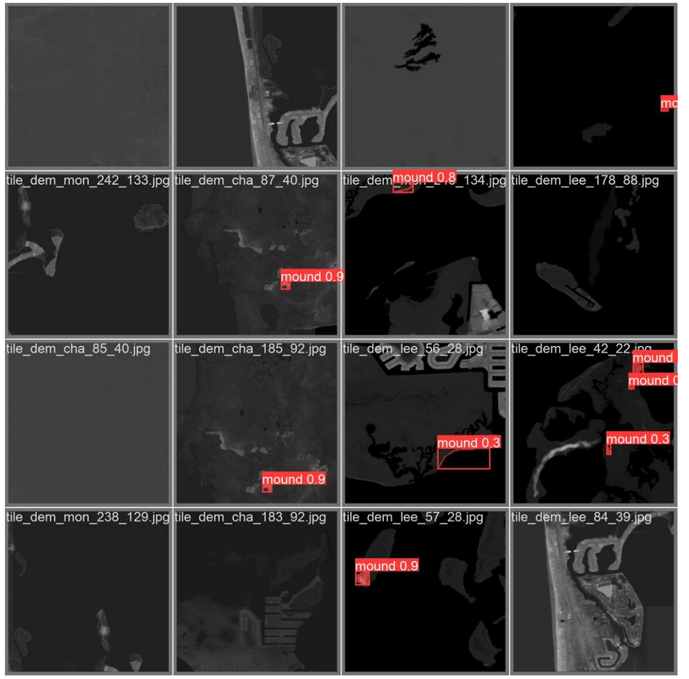


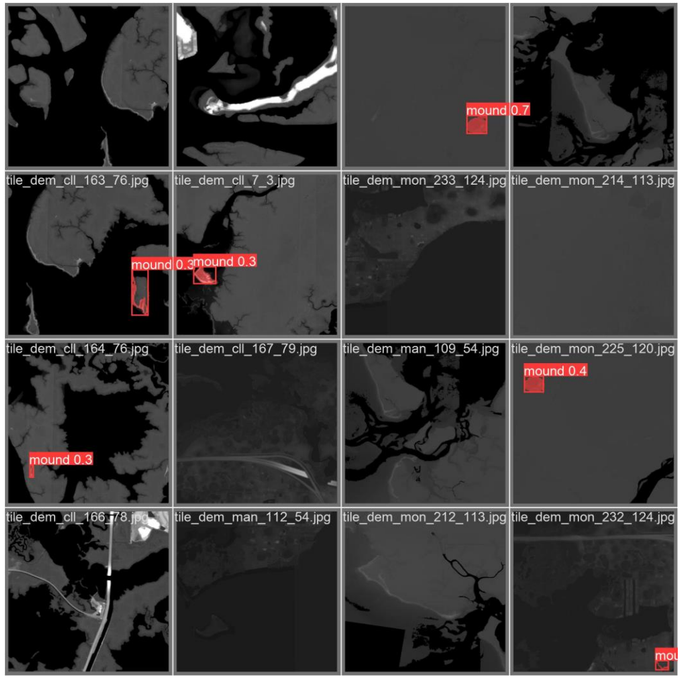
. . . or makes very incorrect predictions because **shell mound** is not one of the categories it is trained on

Results

Lidar-derived Digital Elevation Model (USGS, FDEM, NOAA)

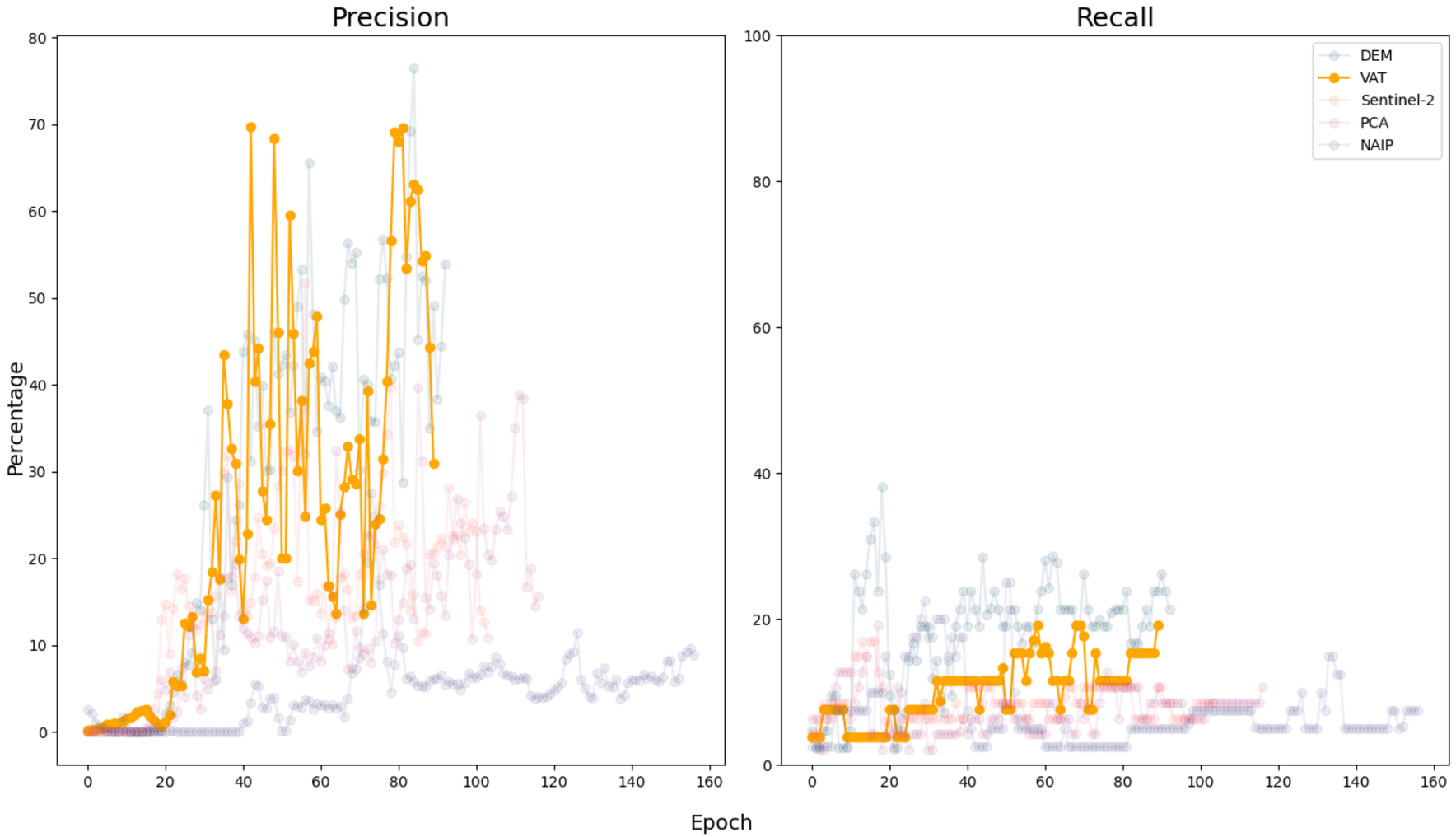


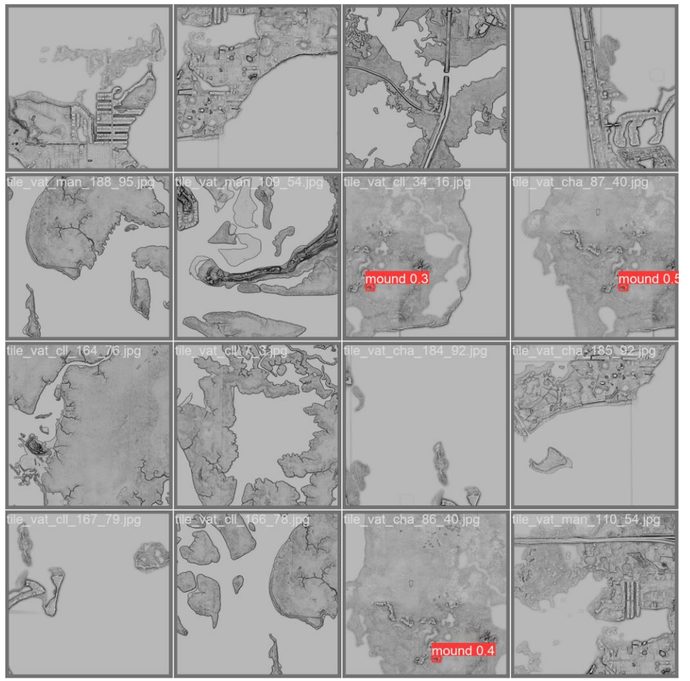


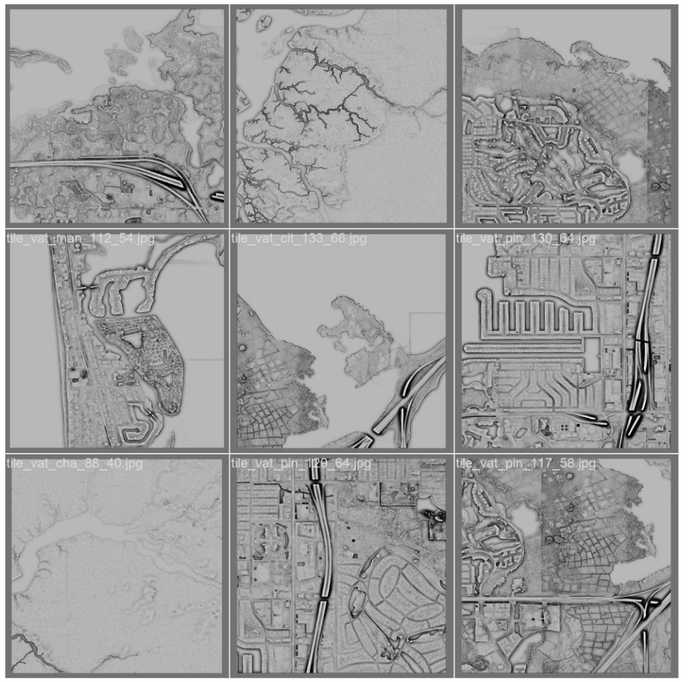


Results

Visualization for Archaeological Topography (Relief Visualization Toolbox)

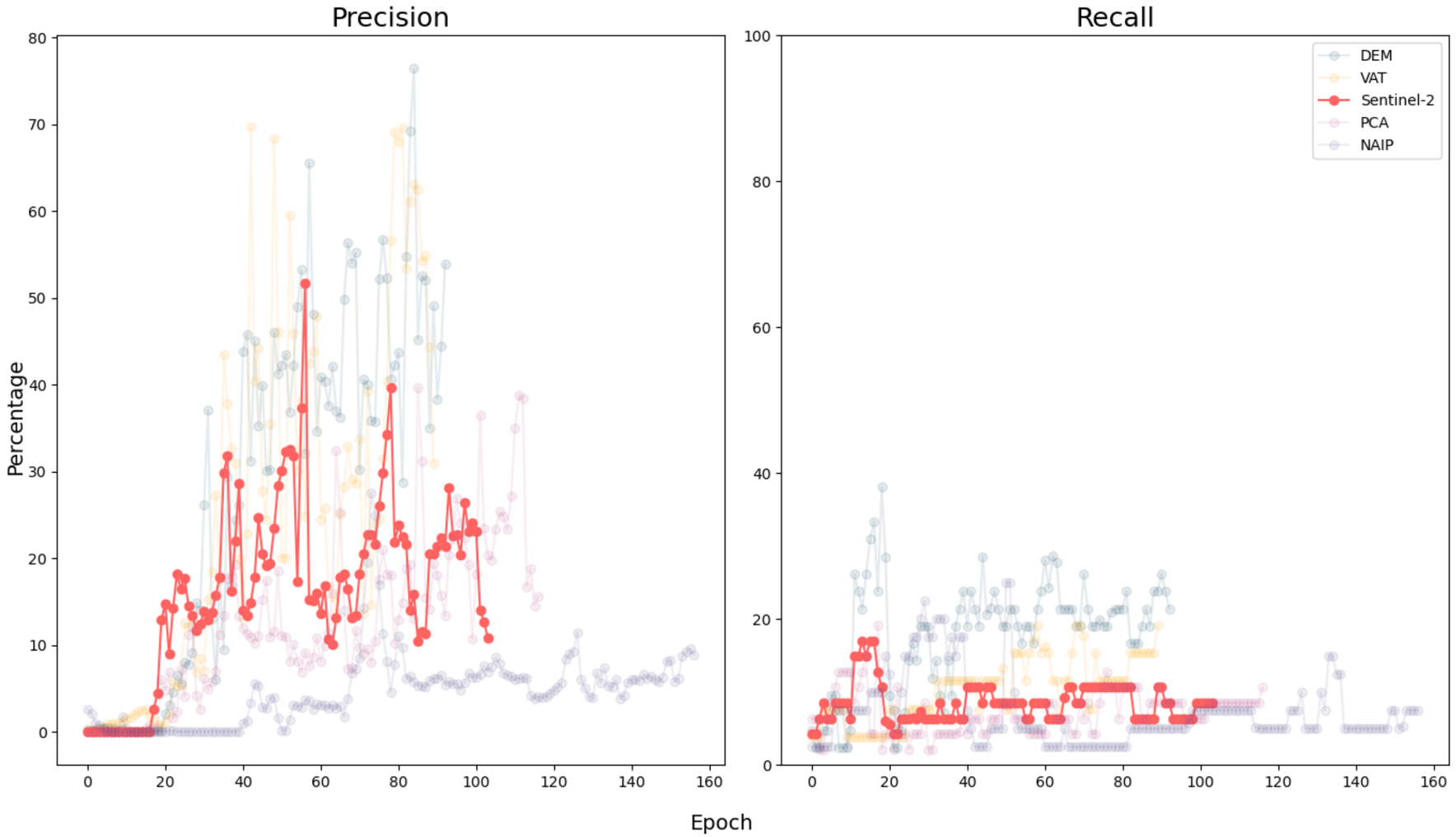


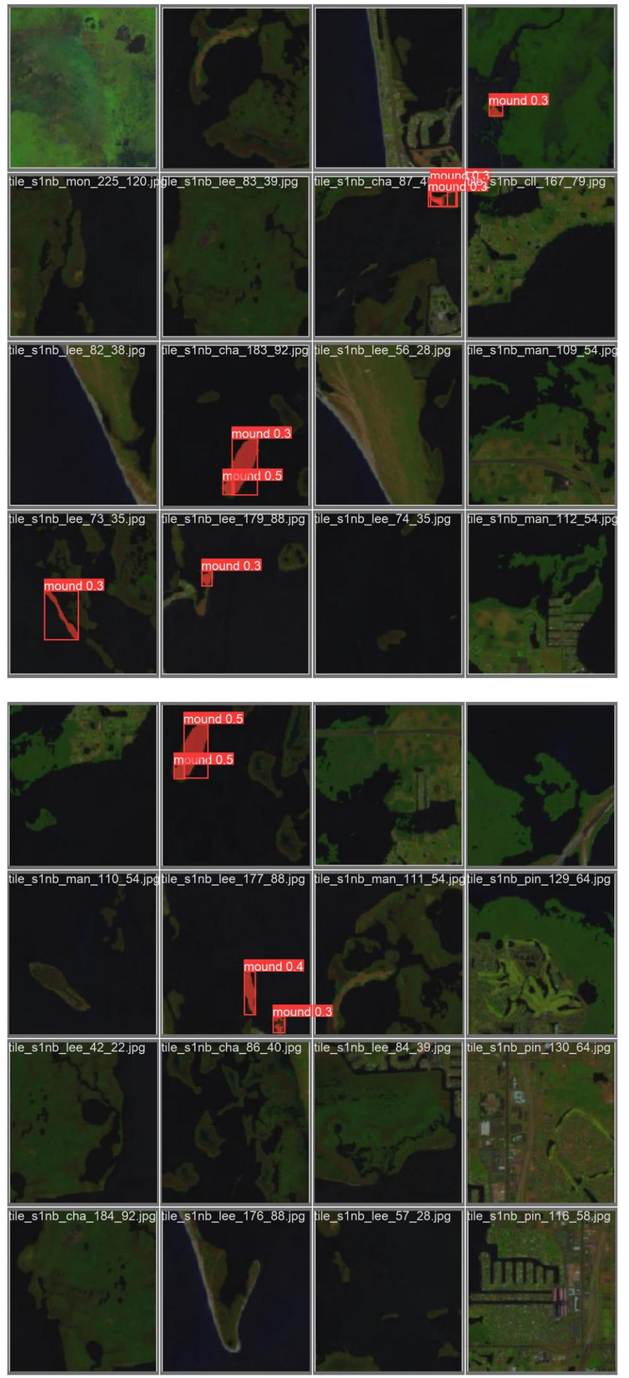




Results

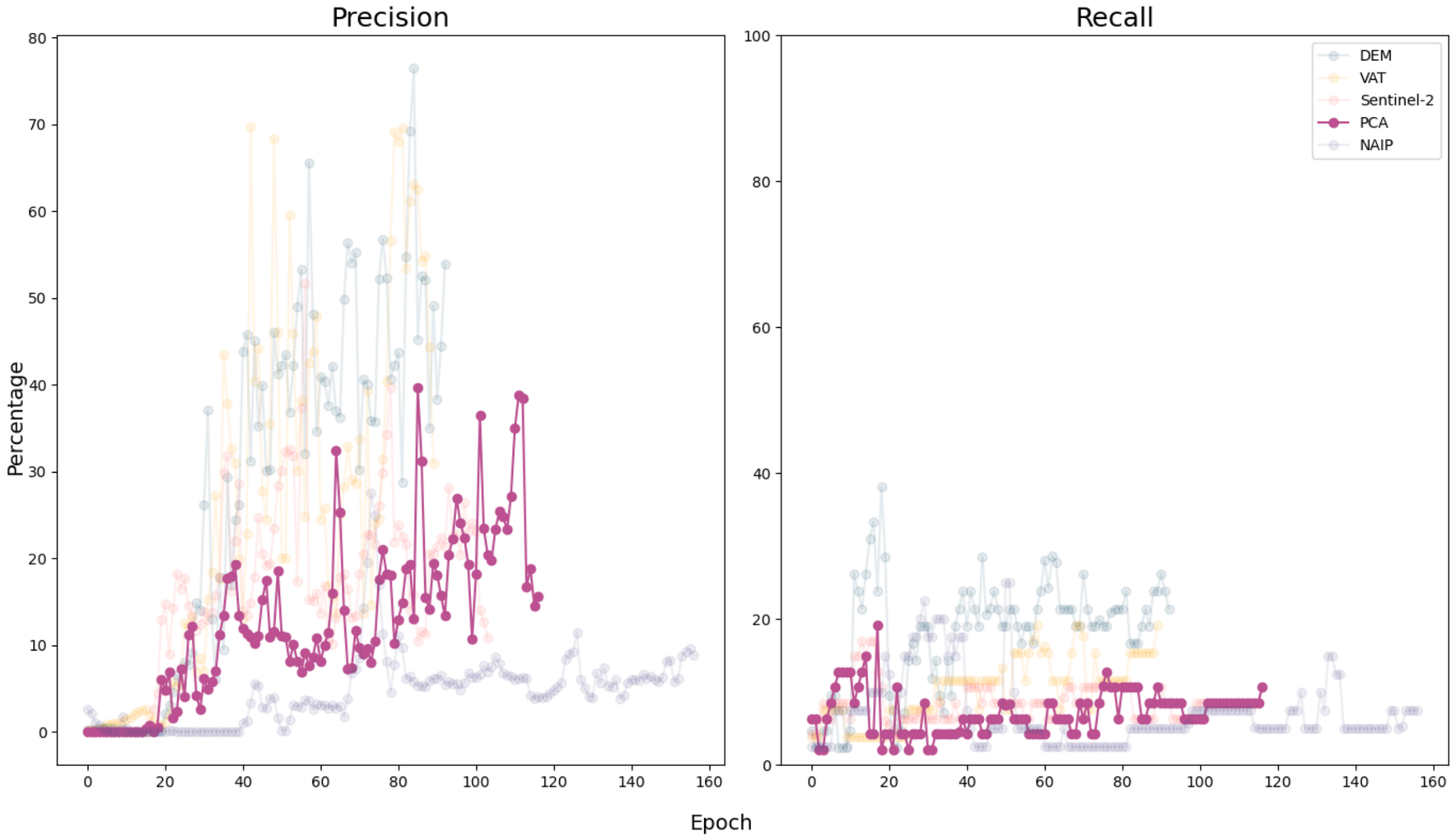
Sentinel-2 Mosaic (Bands 11, 8, 2)

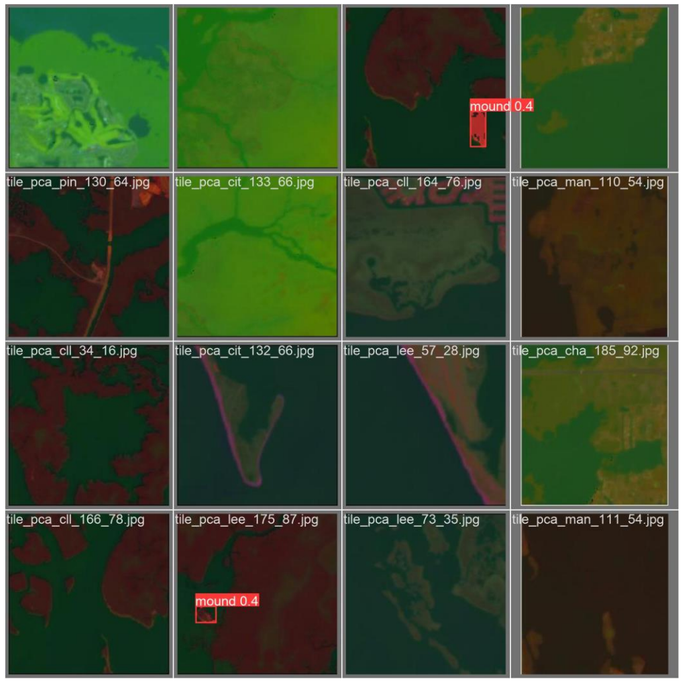


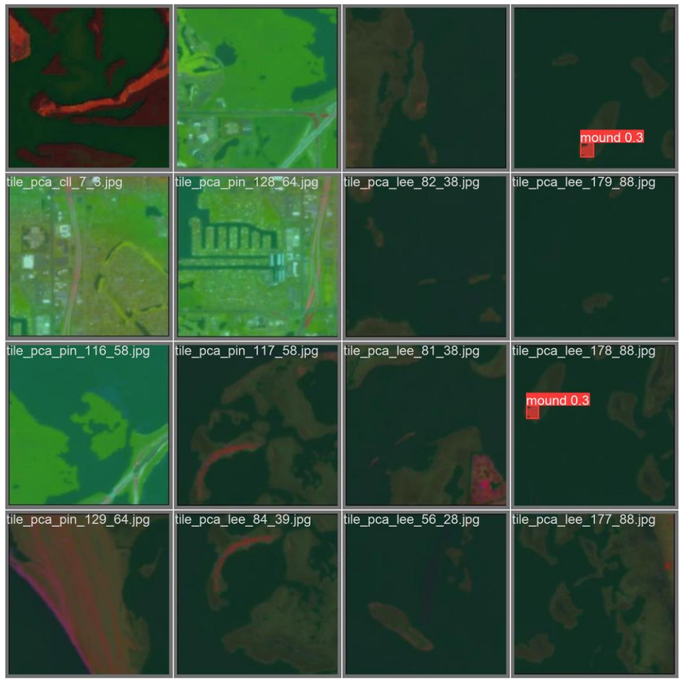


Results

Principal Components Analysis of Sentinel-2 Bands and Lidar DEM

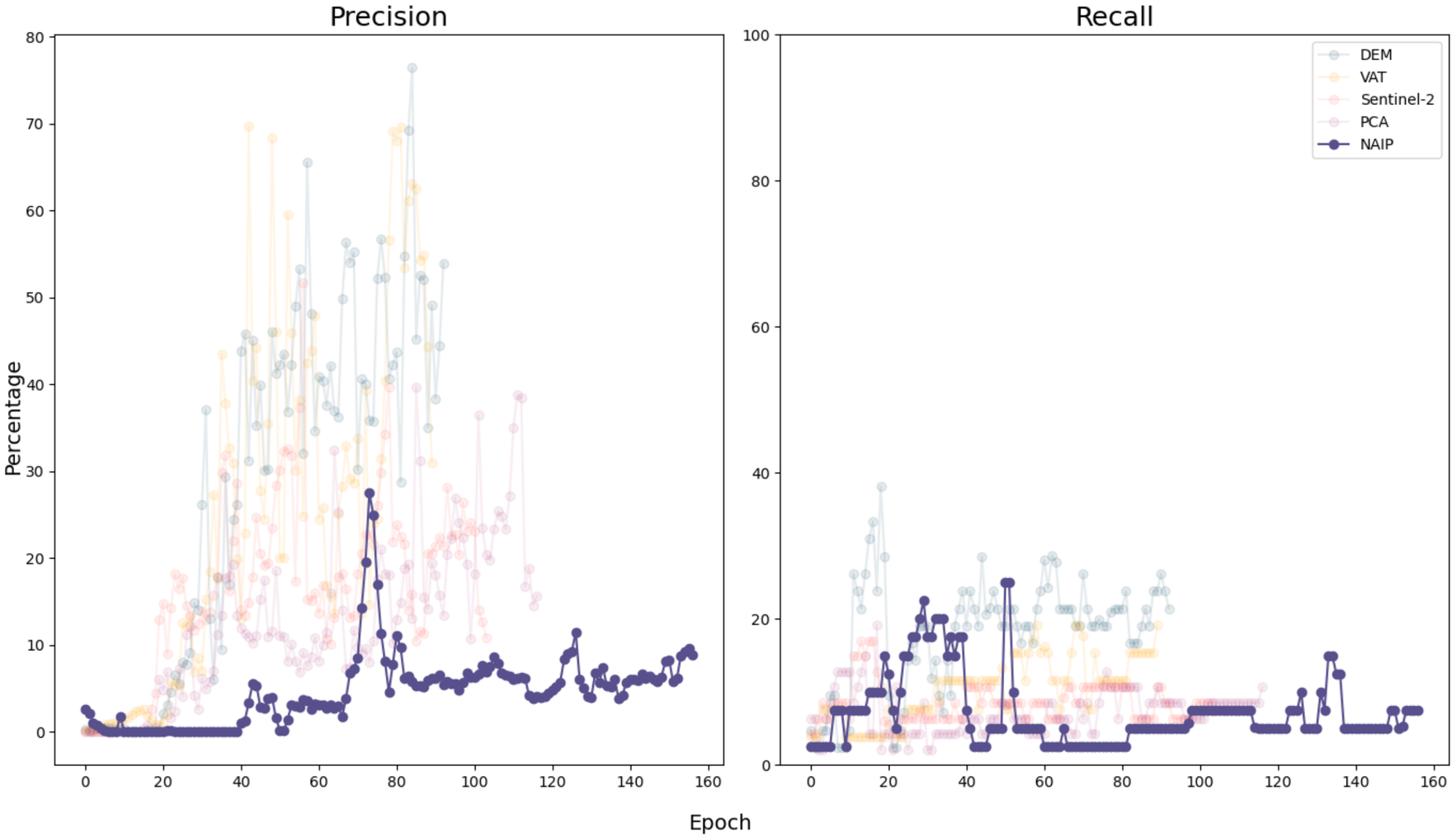


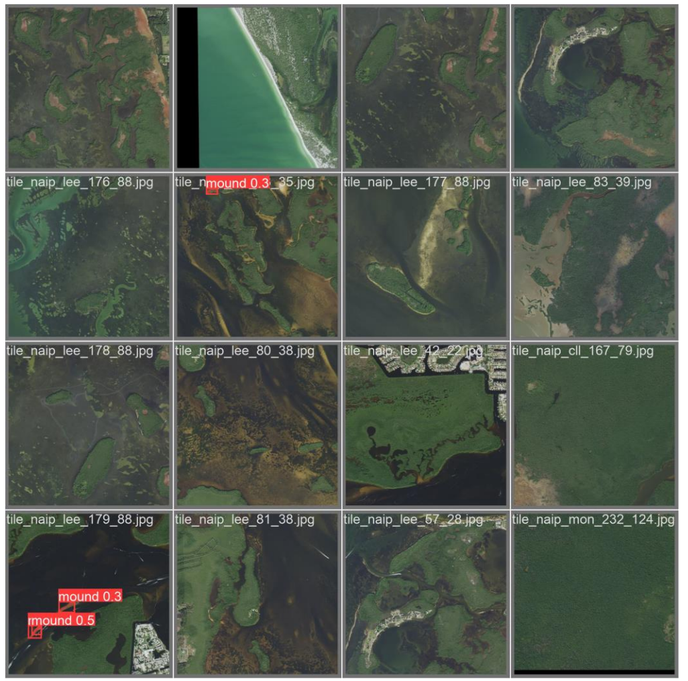


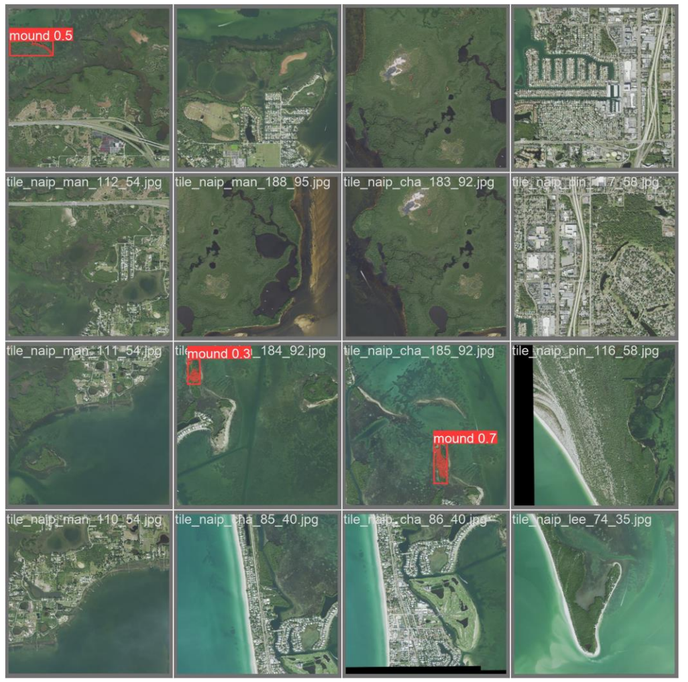


Results

National Agriculture Imagery Program

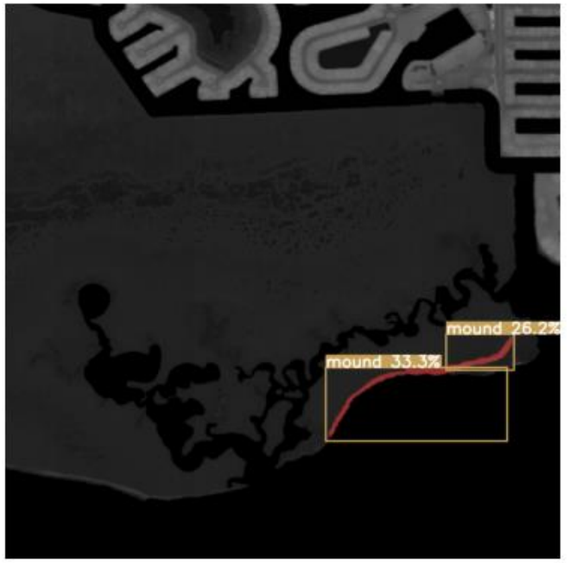


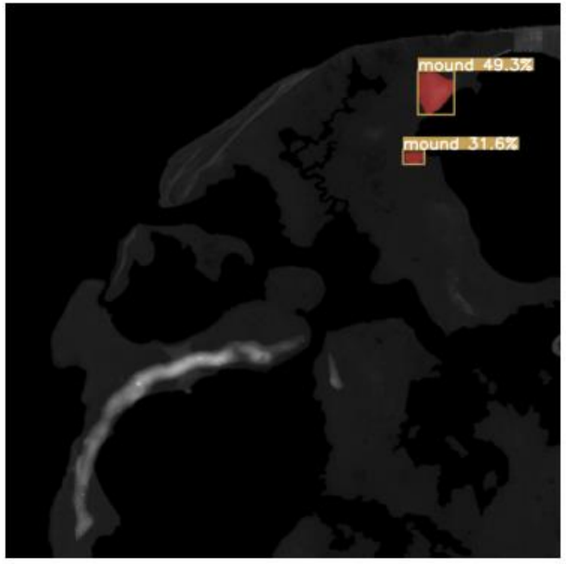


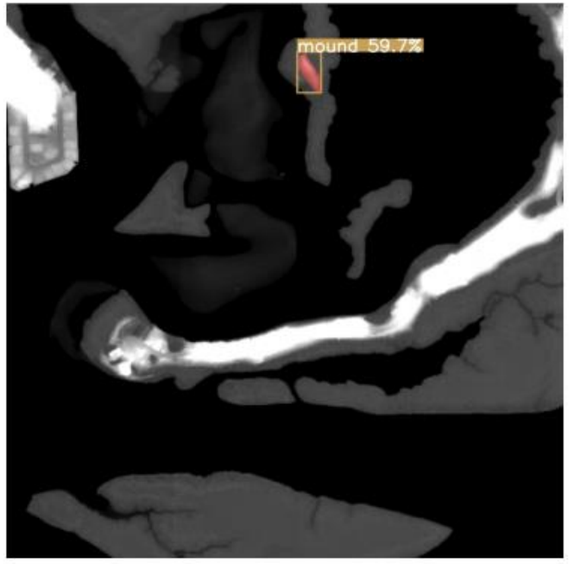


SHELL MOUND SEGMENTATIONS

The model detected shell mounds we know exist . . .



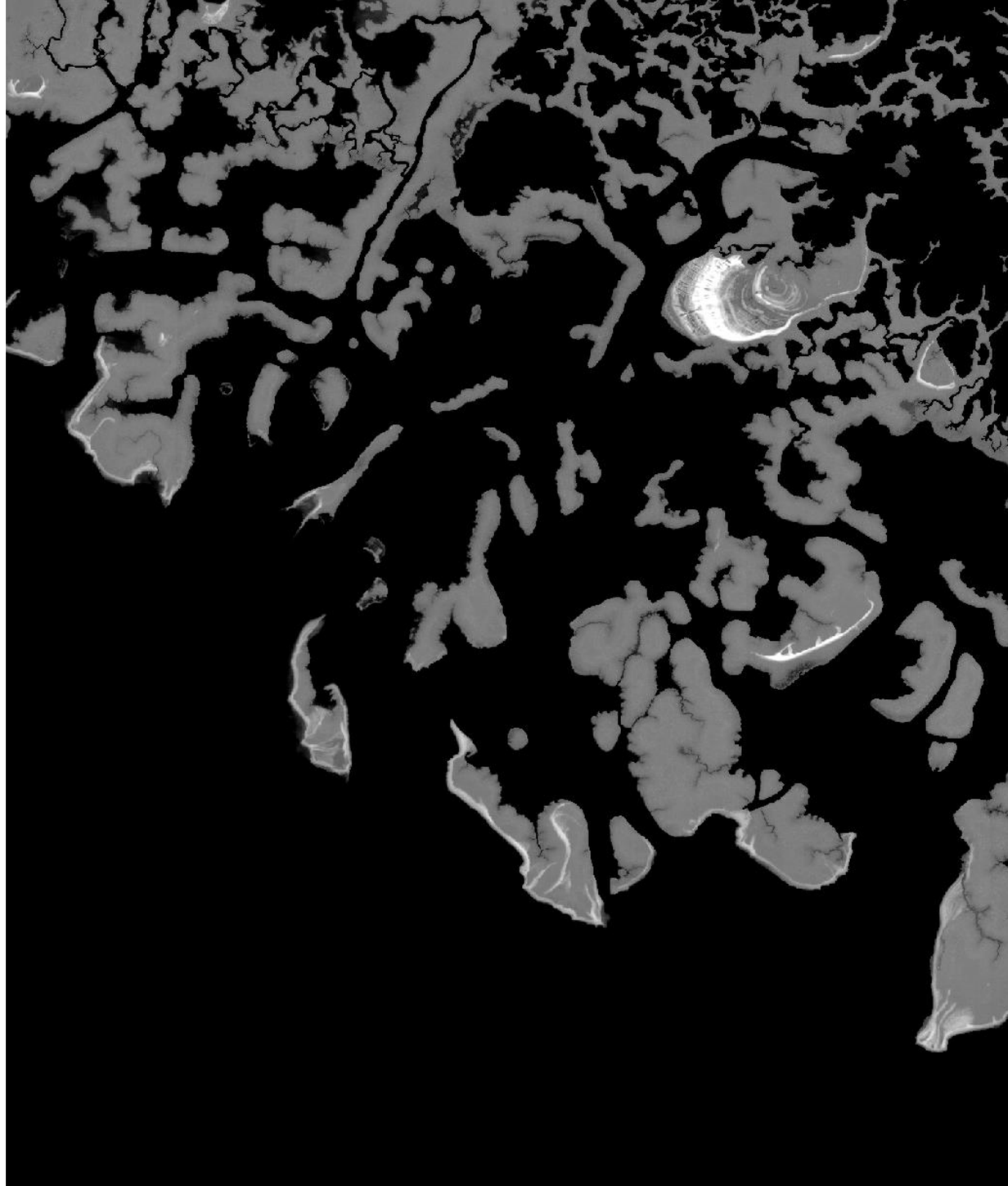




. . . and found potential new mounds we didn’t know about

KEY TAKEAWAYS

- We found the best results when the model was trained on high-resolution LiDAR DEM data
- The model misses many shell mounds, but of the ones it does detect, it is fairly accurate
- The model can segment shell mounds in different shapes and sizes



IMPLICATIONS

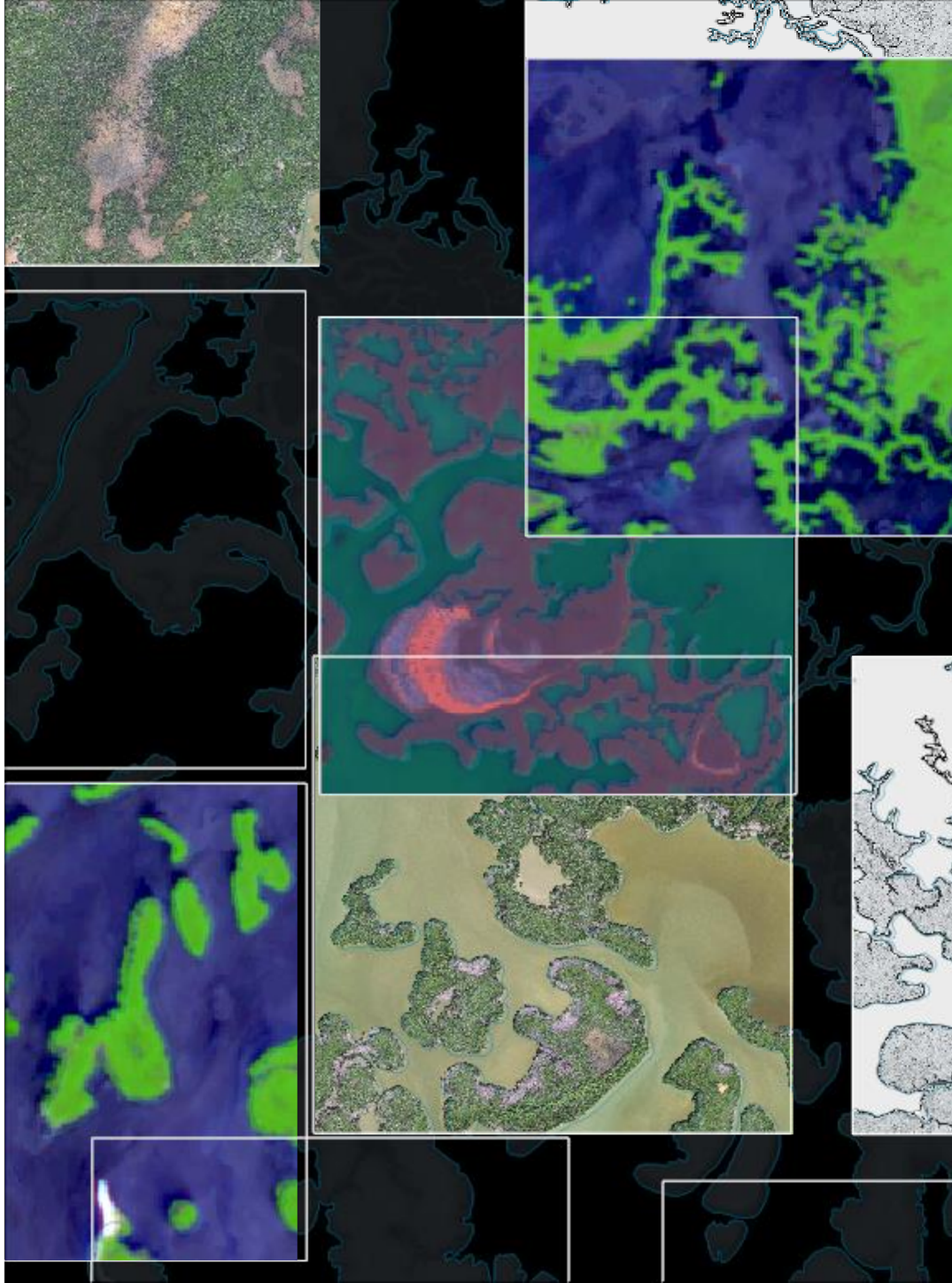
- Many shell mounds from the past have since been destroyed, and possibly several without formal documentation
- Having accurate boundaries of shell mounds is crucial for preserving and protecting these sites

Remains of a shell mound destroyed to make roads

Photographed by John Kunkel Small, near Daytona Beach, Florida. December 1919 (State Archives of Florida, Florida Memory)

FUTURE WORK

- Test other AI models (such as Mask-RCNN)
- Train the model on other remote sensing data that can capture the unique characteristics of shell mounds
- Use the predicted shell mound outlines to calculate statistics such as change in vegetation and land use/land cover over time



THANK YOU

Collaboration with:
Annisa Karim
Adam Knight
Alison Gieson
Mike Duey
Justin Lamb
Robert Ballard
Alison Spikowsky
Bill Spikowsky
Friends of the Randell Research Center
Friends of the Mound House
Calusa Land Trust
Florida Bureau of Archaeological Research
University of Georgia
Penn State University

Funded by: National Science Foundation (BCS-2304807);
University of Florida Biodiversity Institute Seed Grant, 2024

REFERENCES

2018 USGS Lidar DEM: Southwest, FL. *NOAA Office for Coastal Management*. https://noaa-nos-coastal-lidar-pds.s3.amazonaws.com/dem/USGS_FL_Southwest_2018_9049/index.html

Data Access Viewer, *NOAA Office for Coastal Management*. https://coast.noaa.gov/digitalcoast/tools/dav.html

Erlandson, Jon M. Shell middens and other anthropogenic soils as global stratigraphic signatures of the Anthropocene. 2013. *Anthropocene*, 4, pp. 24-32.

Florida Master Site File. *Florida Division of Historical Resources*, Florida Department of State. https://dos.fl.gov/historical/preservation/master-site-file/

Florida Natural Areas Inventory. (2010). Guide to the natural communities of Florida: 2010 edition, Tallahassee, FL. https://www.fnai.org/species-communities/natcom-guide

Guyot, A., Lennon, M., & Hubert-Moy, L. (2021). Objective comparison of relief visualization techniques with deep CNN for Archaeology. *Journal of Archaeological Science: Reports*, *38*, 103027. https://doi.org/10.1016/j.jasrep.2021.103027

Jocher, G., Qiu, J., & Chaurasia, A. (2023). Ultralytics YOLO (Version 8.0.0) [Computer software]. https://github.com/ultralytics/ultralytics

National Agriculture Imagery Program. (2021). U.S. Department of Agriculture.

Office for Coastal Management, 2024: NOAA Office for Coastal Management Coastal Inundation Digital Elevation Model: Florida, SW, https://www.fisheries.noaa.gov/inport/item/70057.

Office for Coastal Management Partners, 2024: 2007 Florida Division of Emergency Management (FDEM) Lidar Project: Southwest Florida, https://www.fisheries.noaa.gov/inport/item/49677.

Orengo, H.A., Conesa, F.C., Garcia-Molsosa, A., Lobo, A., Green, A.S., Madella, M., Petrie, C.A. (2020). Automated detection of archaeological mounds using machine-learning classification of multisensor and multitemporal satellite data. *Proceedings of the National Academy of Sciences*, 117(31), 18240–18250, https://doi.org/10.1073/pnas.2005583117

Small, John Kunkel. *Destroyed shell mounds*. 1919. State Archives of Florida, Florida Memory. https://www.floridamemory.com/items/show/49833

Taylor, K., & Lennon, J. (2011). Cultural landscapes: a bridge between culture and nature? *International Journal of Heritage Studies*, *17*(6), 537–554. https://doi.org/10.1080/13527258.2011.618246

Turtle Mound near New Smyrna Beach. 1937 (circa). State Archives of Florida, Florida Memory. https://www.floridamemory.com/items/show/34151

Kokalj, Ž., Somrak, M. 2019. Why Not a Single Image? Combining Visualizations to Facilitate Fieldwork and On-Screen Mapping. *Remote Sensing 11*(7): 747.

Zakšek, K., Oštir, K., Kokalj, Ž. 2011. Sky-View Factor as a Relief Visualization Technique. *Remote Sensing 3*(2): 398-415 .