UC San Diego

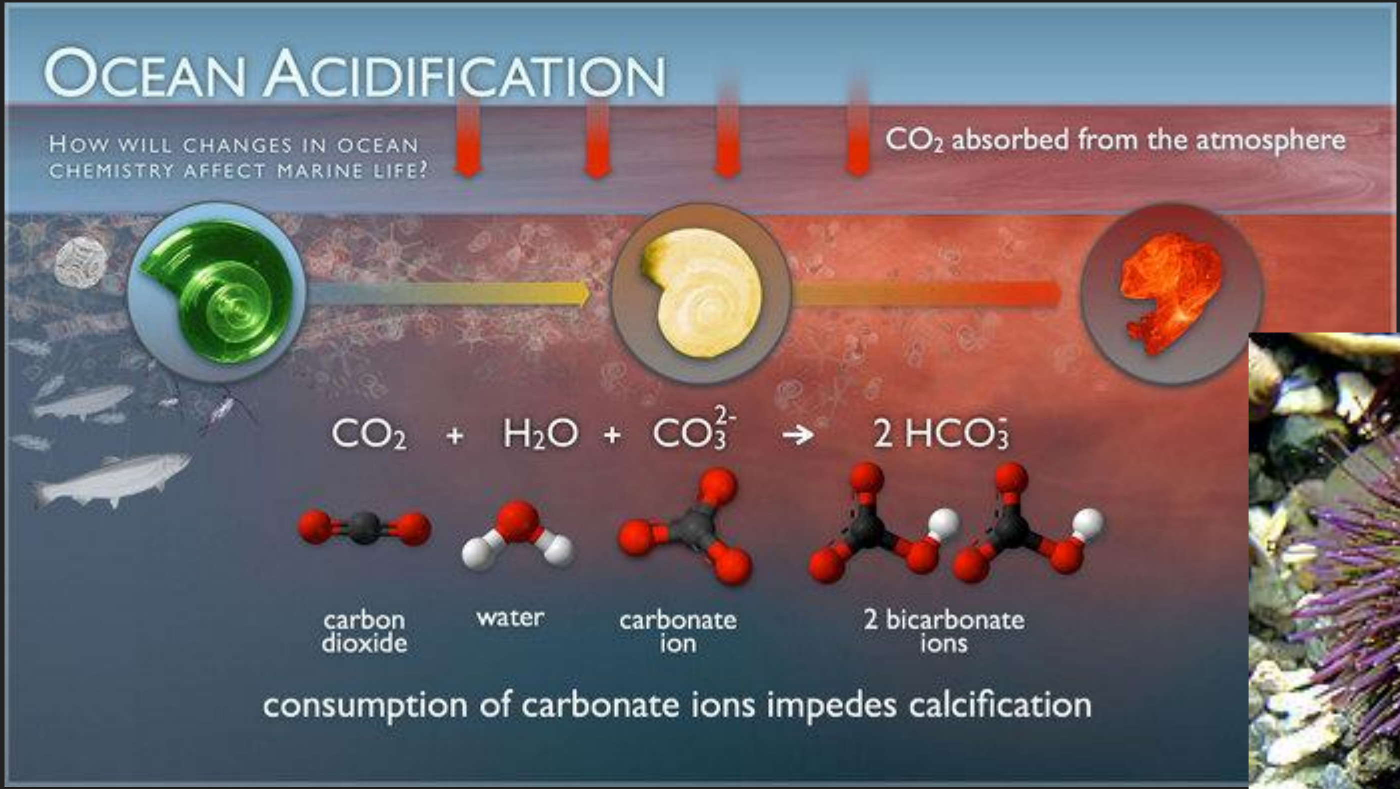
ENGINEERS FOR EXPLORATION

2017 Research Experience for Undergraduates

SmartFin

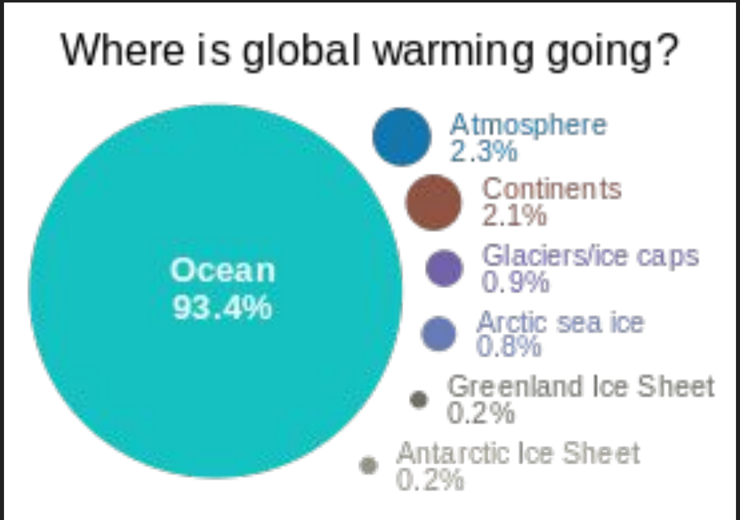
Lysny Woodahl

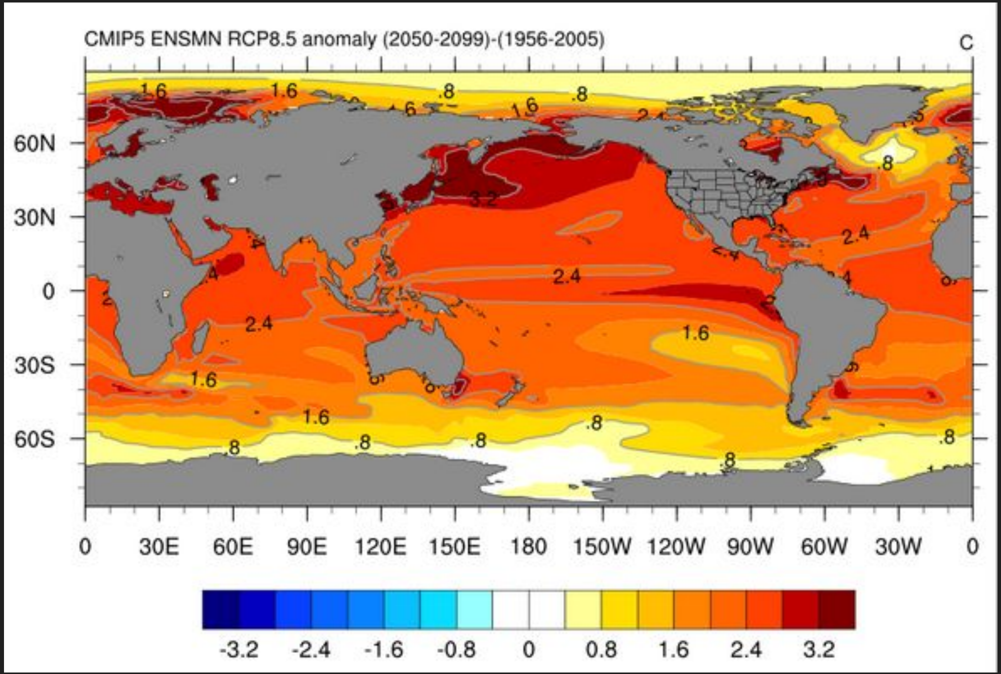
The Changing Ocean



Strongylocentrotus purpuratus

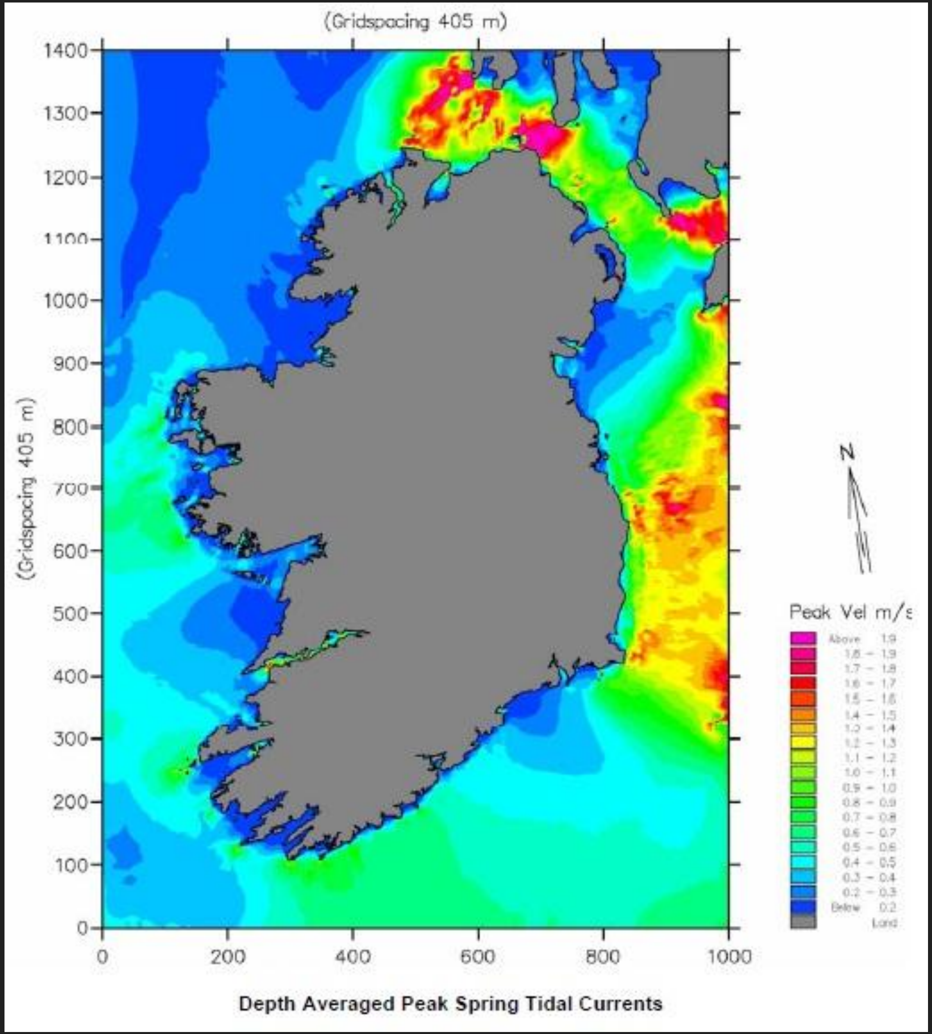
The Changing Ocean





Predicted change based on previous change.

Previous Methods

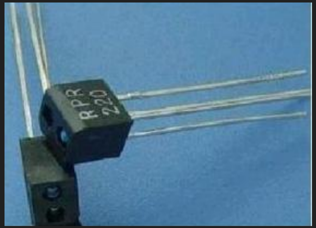


SmartFin

What is it?

How does it work?

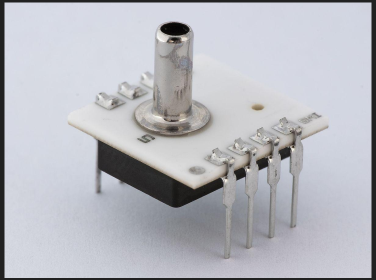
Rebuilding the Fin



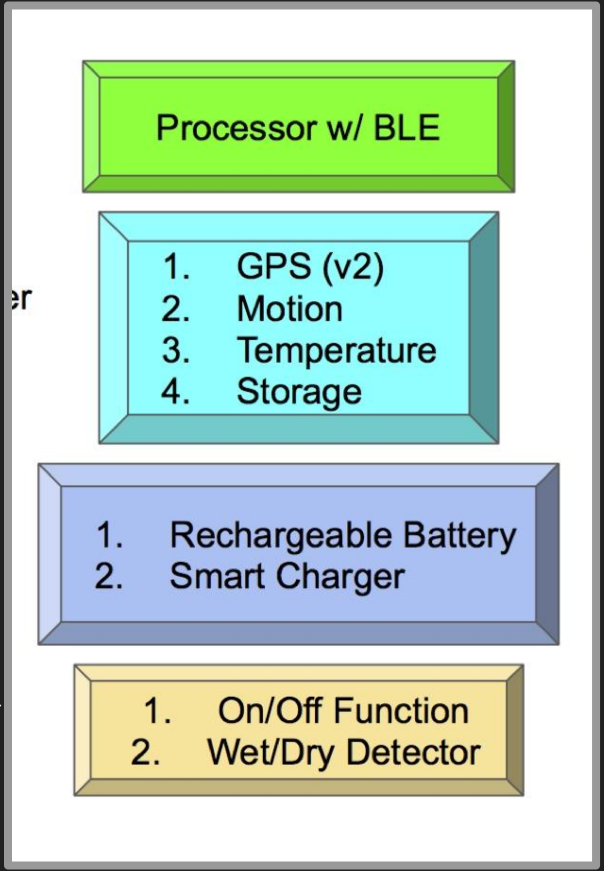
opto-sensor

resistive
sensing
circuit

moisture
sensor

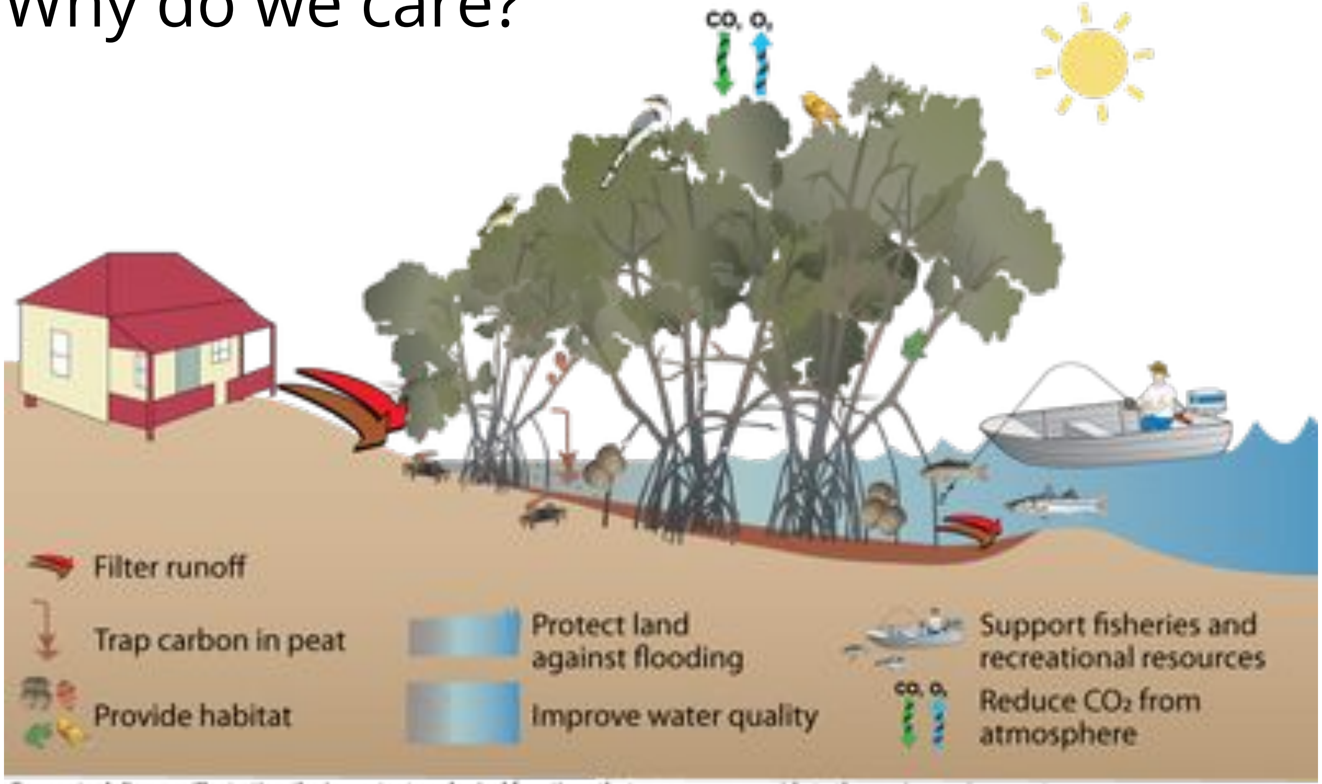


pressure
sensor



Mangrove Monitoring

Why do we care?



Conceptual diagram illustrating the important ecological functions that mangroves provide to the marine environment.
Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Kruczynski, W.L., and P.J. Fletcher (eds.). 2012. Tropical Connections: South Florida's marine environment. IAN Press, University of Maryland Center for Environmental Science, Cambridge, Maryland. 492 pp.

Threats to mangroves

- Construction
- Agriculture
- Aquaculture

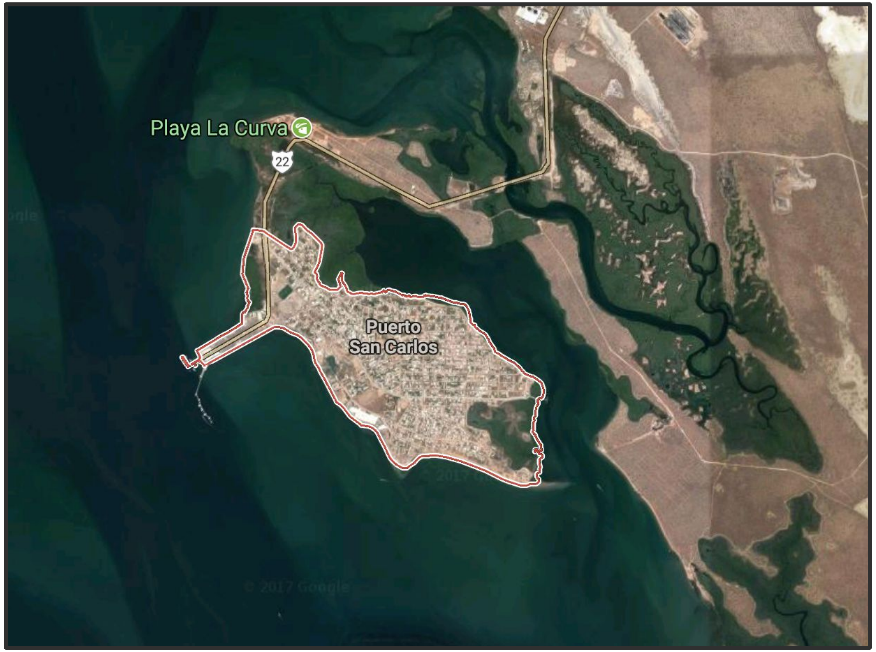
Boots on the ground

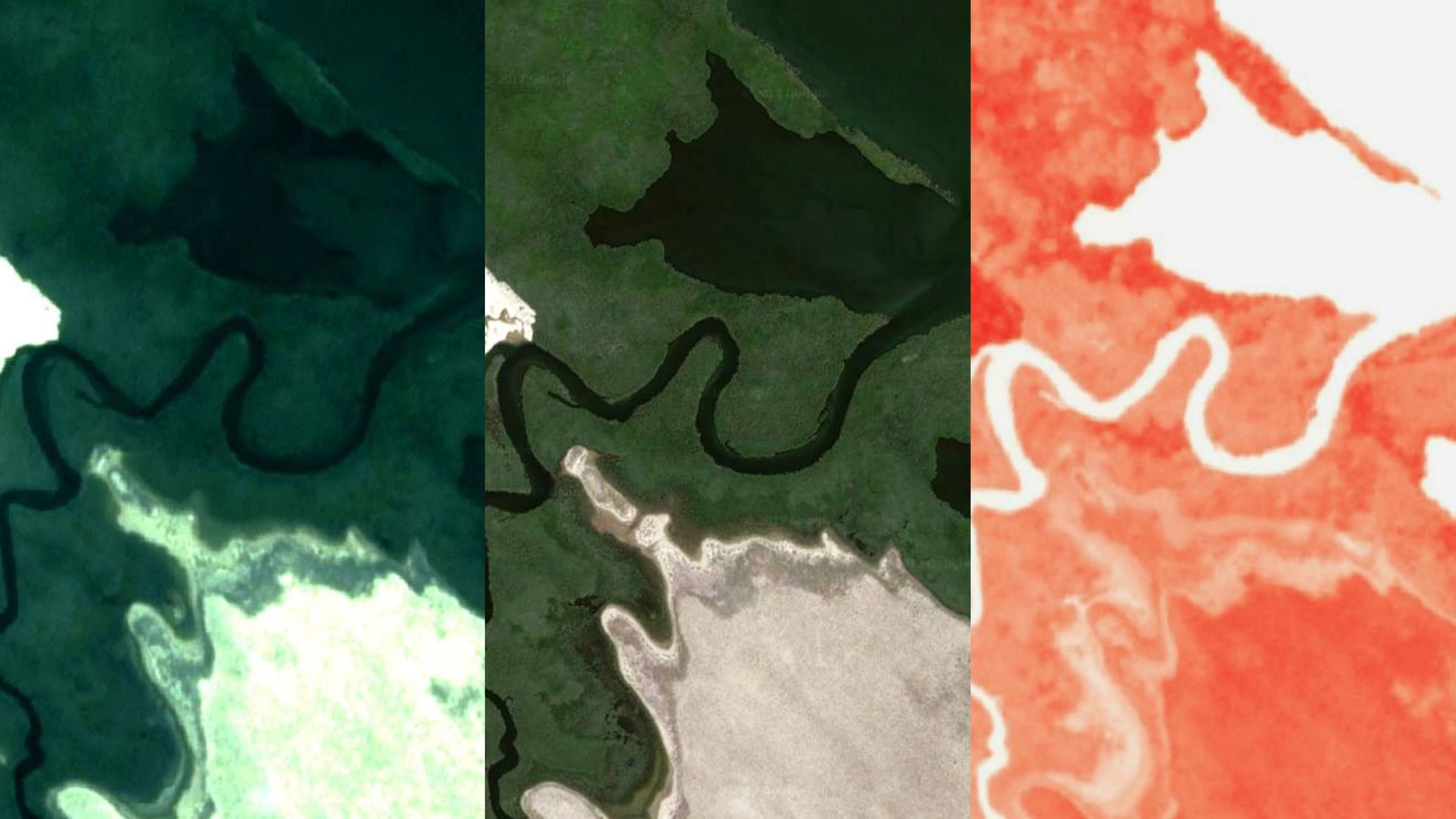
Goals

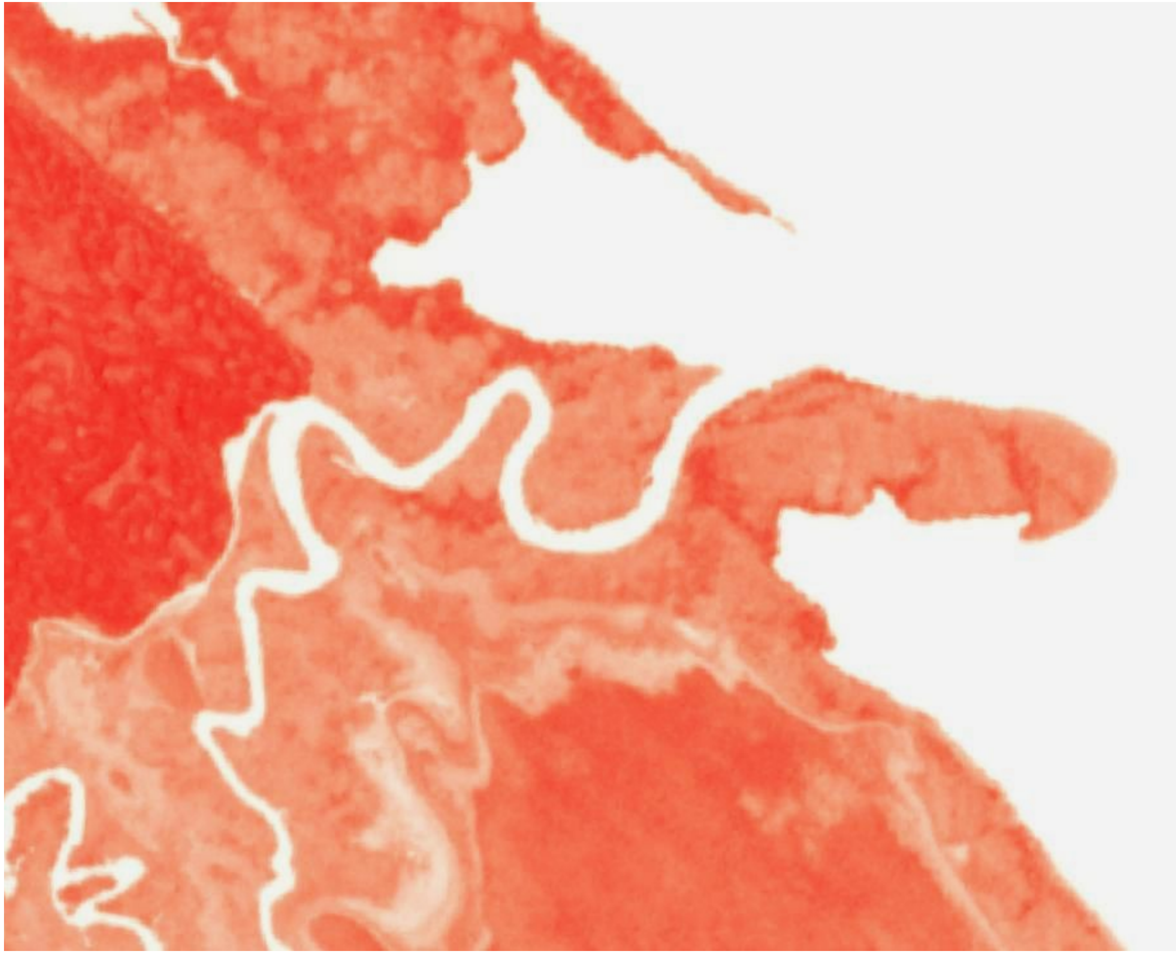
- Large scale spatial and temporal monitoring
  - Detect change in Ecosystems
  - Species Classification
  - Measure Biomass

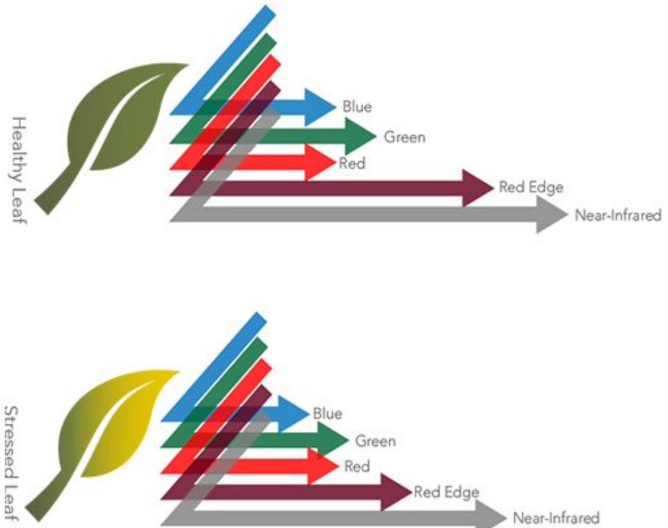
Benefits of Satellite Imagery

- Daily imagery
- Cover Large Areas
- MultiSpectral Imagery
- Track Change








Healthy Leaf
Blue
Green
Red
Red Edge
Near-Infrared
Stressed Leaf
Blue
Green
Red
Red Edge
Near-Infrared

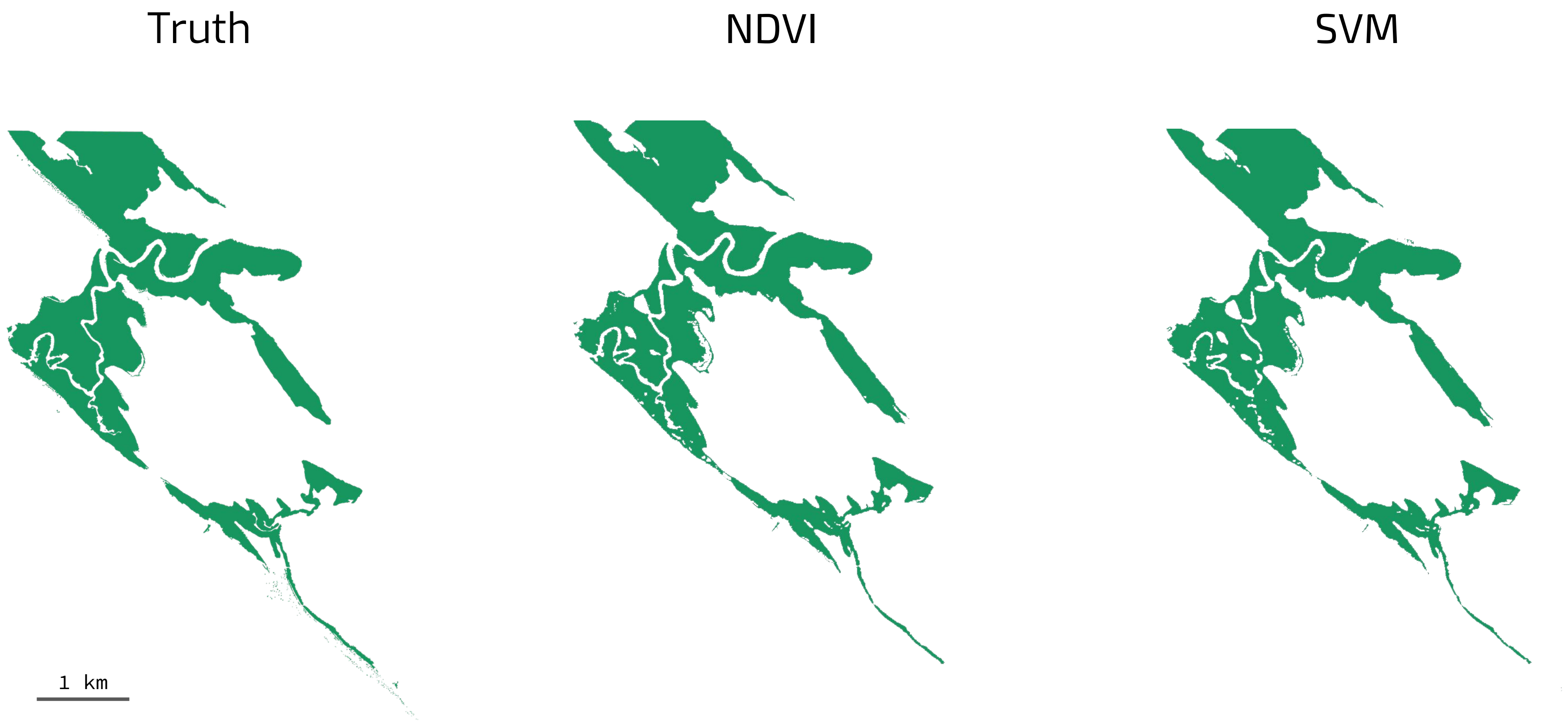
Satellite Imagery

Goals:

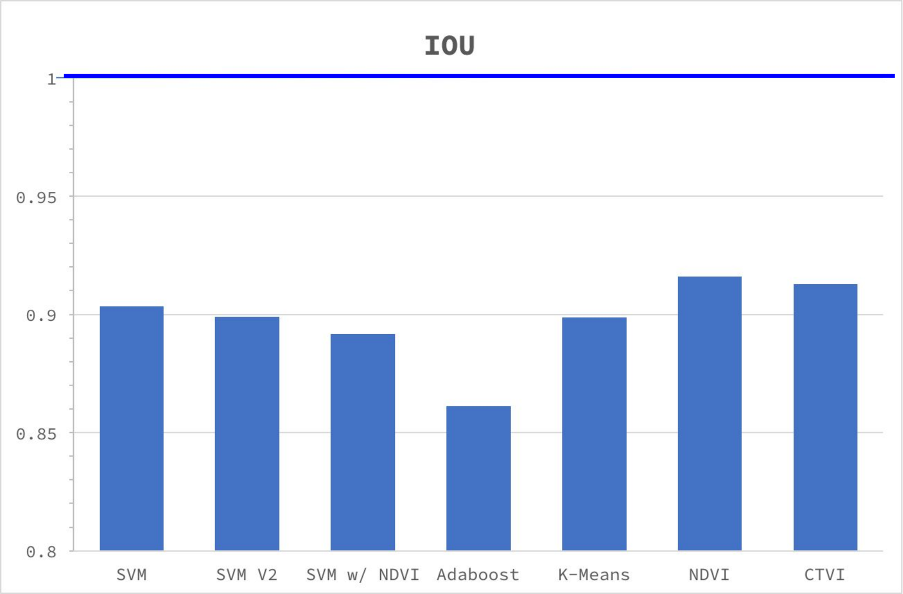
- Vegetation detection
- Mangrove detection

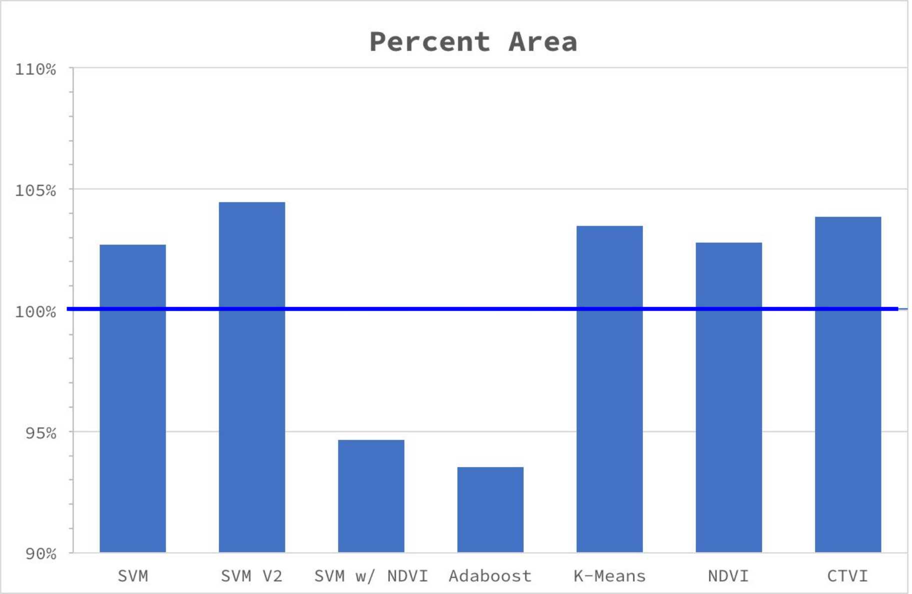
Explored Methods:

- Unsupervised
  - Thresholded NDVI
  - K-Means
- Supervised
  - SVM
  - Adaboost
  - Random Forest

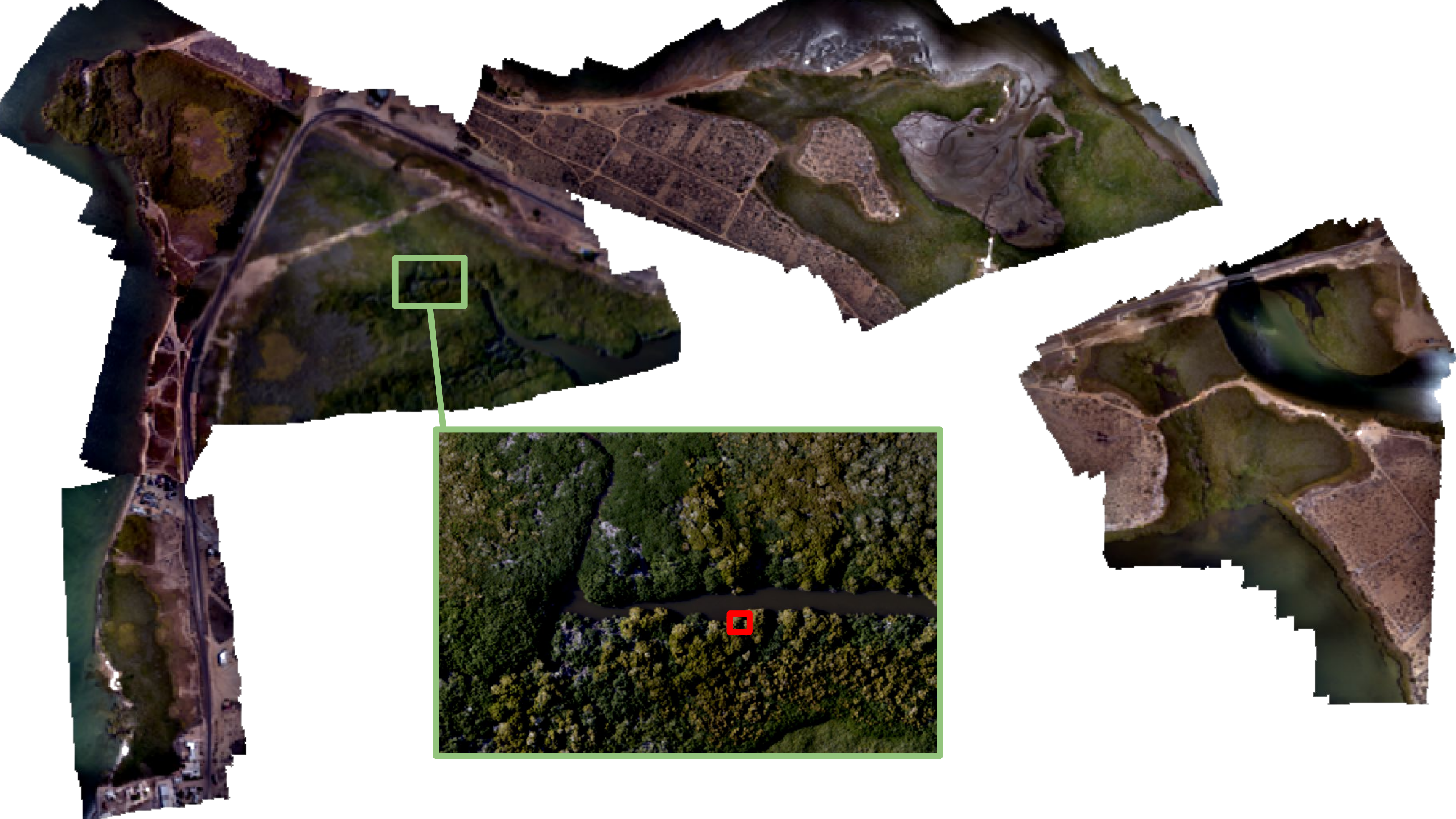

Truth
NDVI
SVM
1 km

Evaluation Metrics





High Resolution Drone Imagery

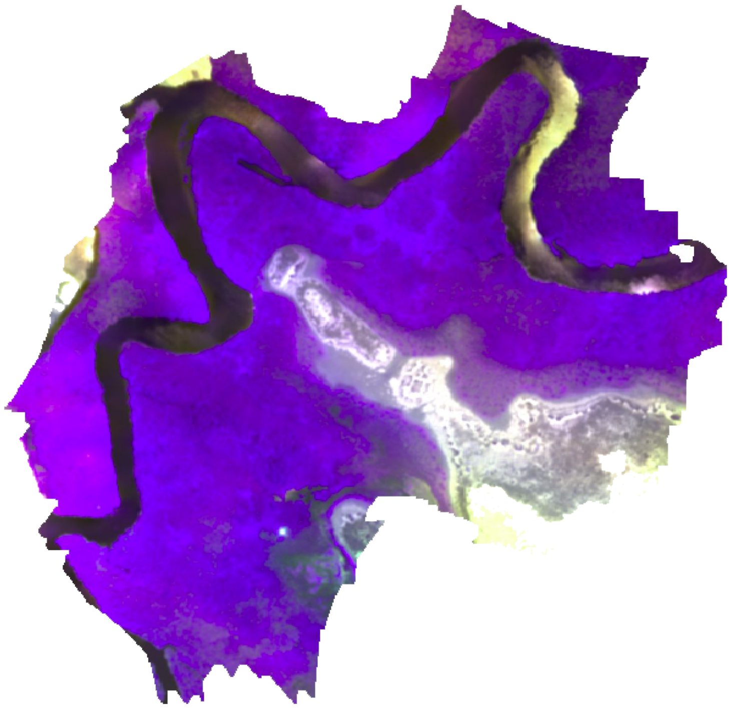


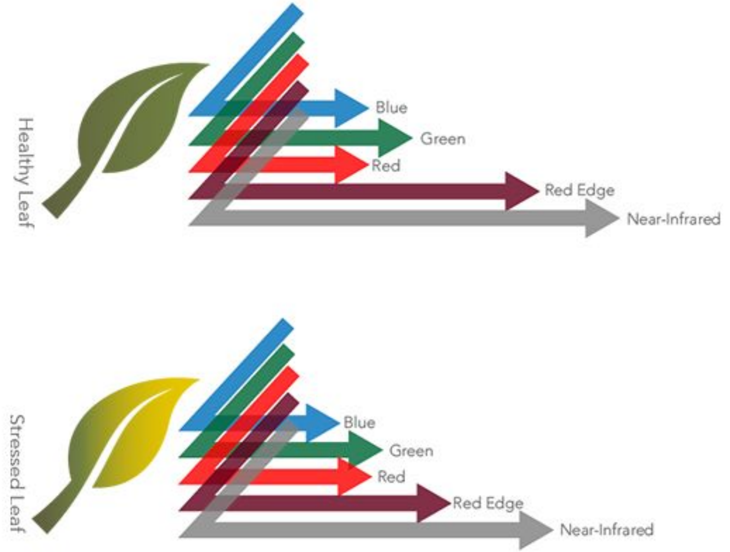
MultiSpectral Imagery:

- RGB (390 ~ 700nm)
- Red Edge (730 - 740nm)
- Near IR (770 - 810nm)

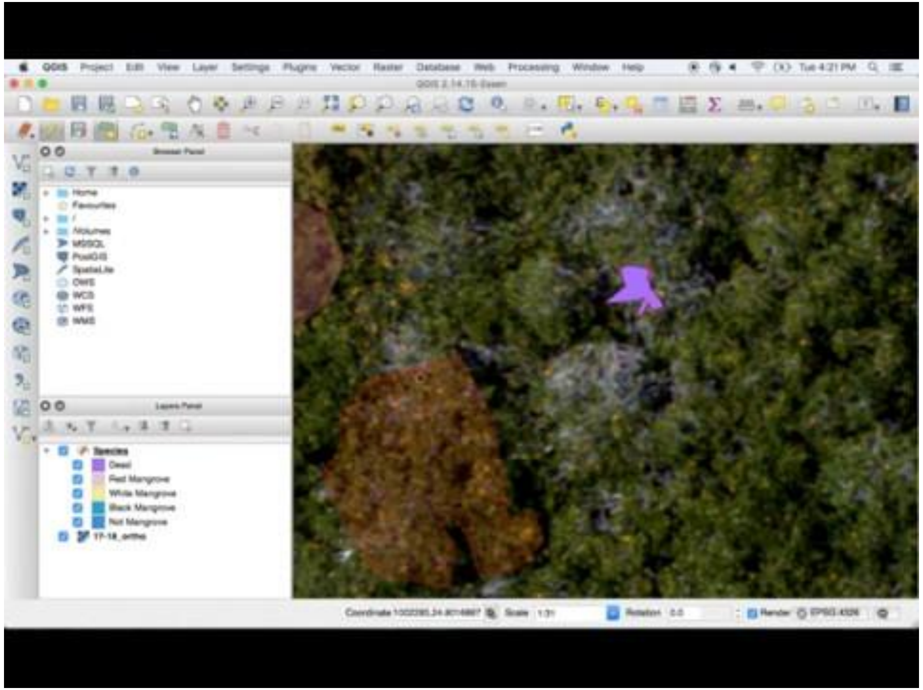
Benefits:

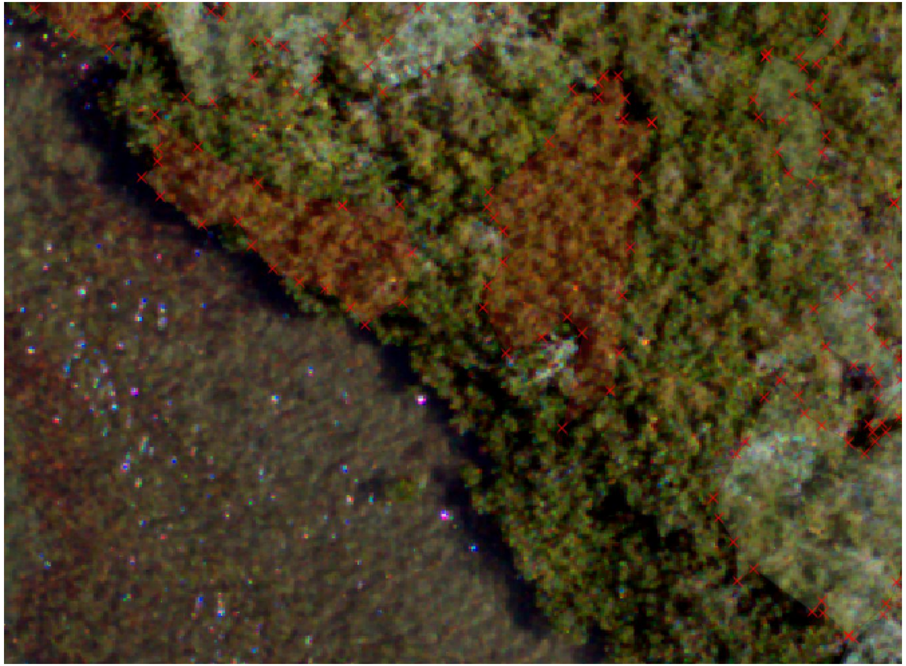
- Species Distribution
- Population Health





Manual Classification





Explored Methods

Drone Imagery:

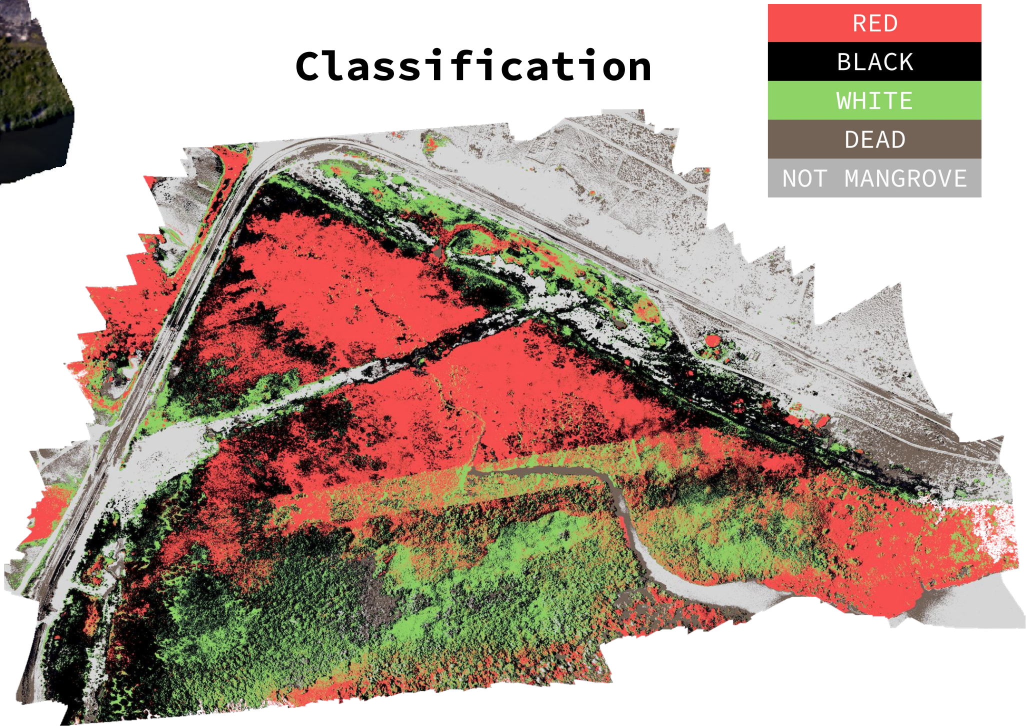
- Mangrove detection
- Mangrove species classification
- Training satellite imagery classifiers

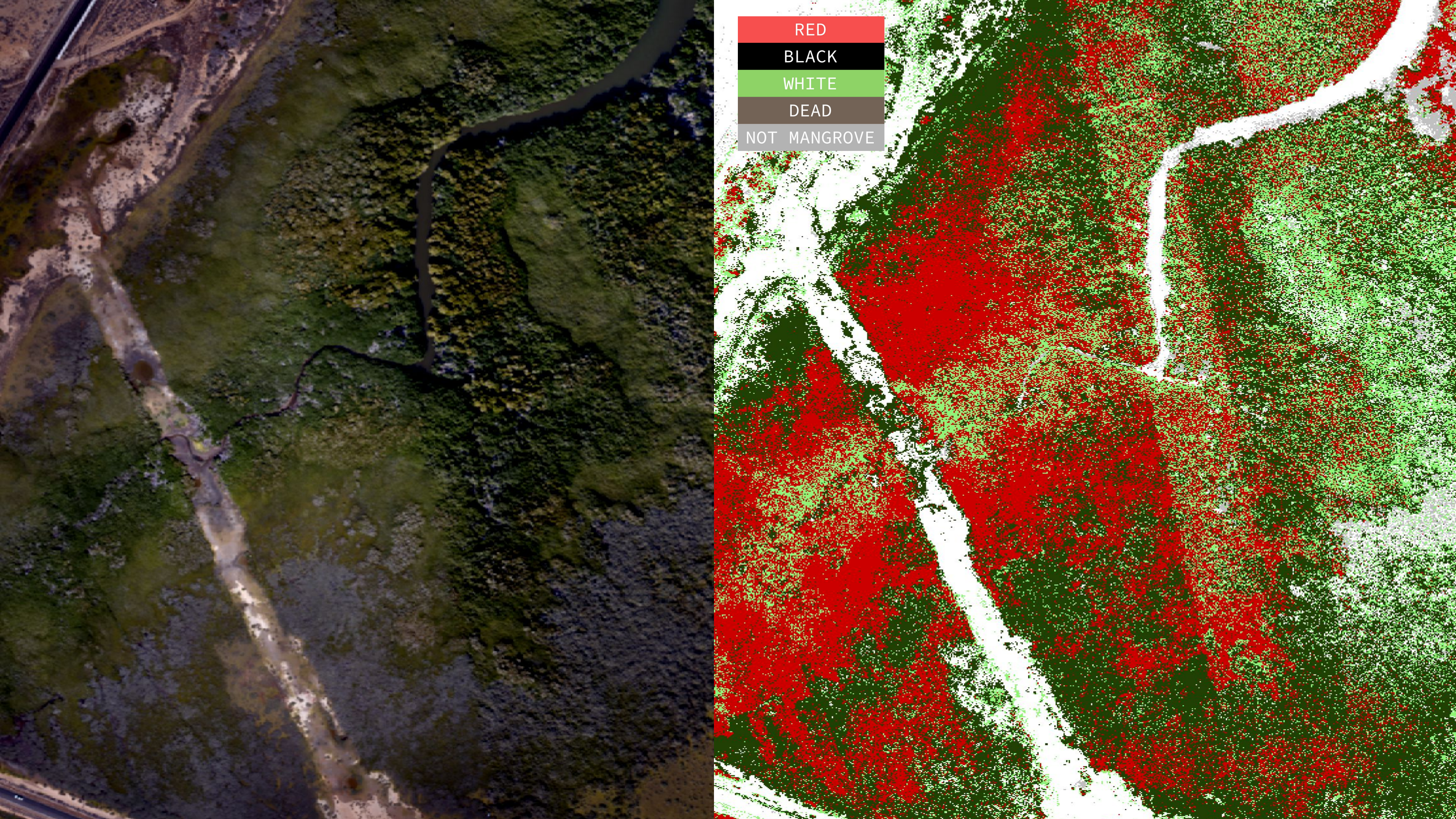
Drone Imagery:

- SVM
- Gradient Boosted Trees
- Random Forest
- Convolutional Neural Networks

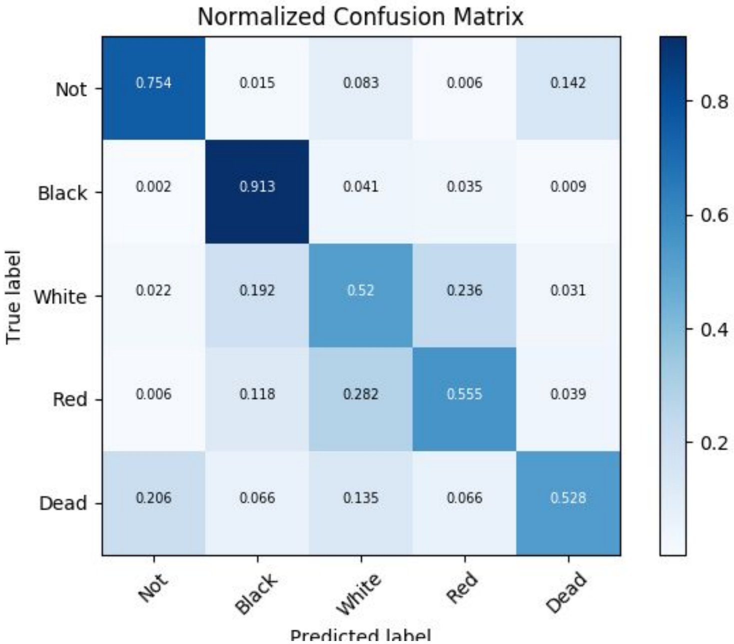
Original

Classification

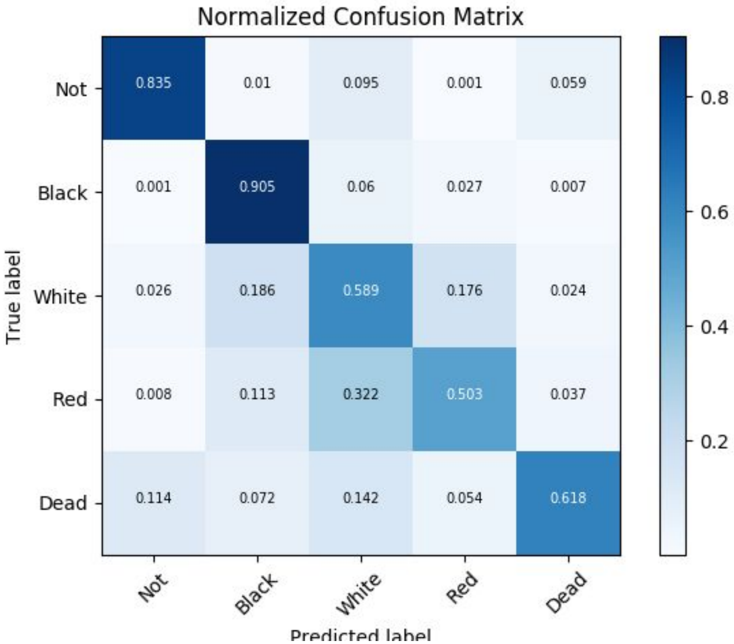



RED
BLACK
WHITE
DEAD
NOT MANGROVE

Drone Image Classification
Preliminary Results



Method: Support Vector Machine with 24000 samples, linear kernel



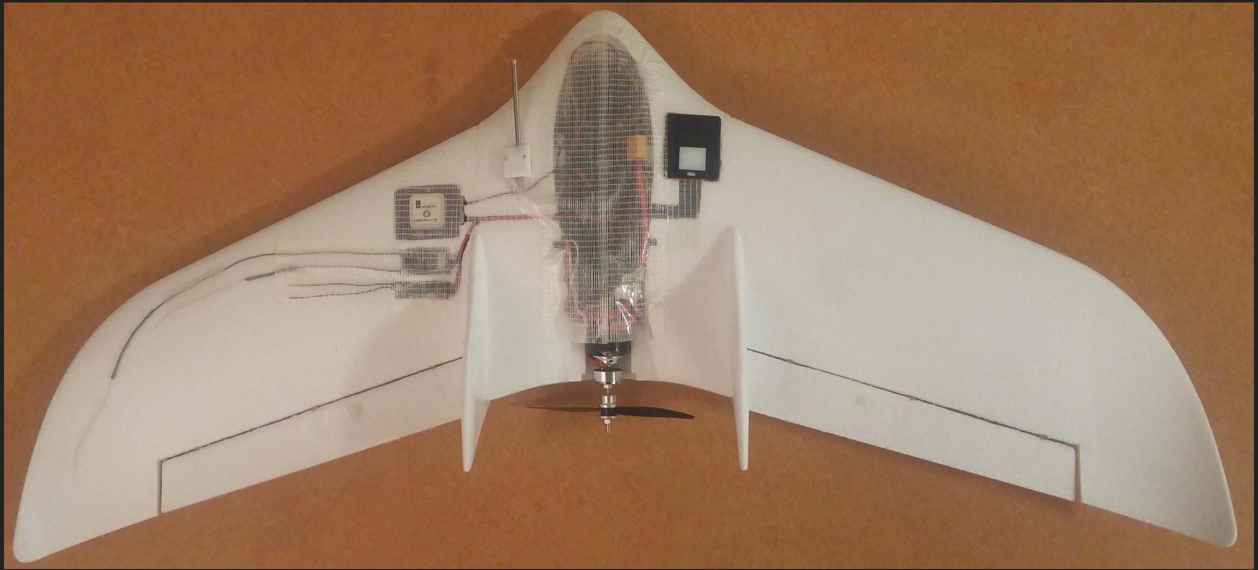
Method: Gradient Boosted Tree with 24000 samples, tree width of 250, tree depth of 4

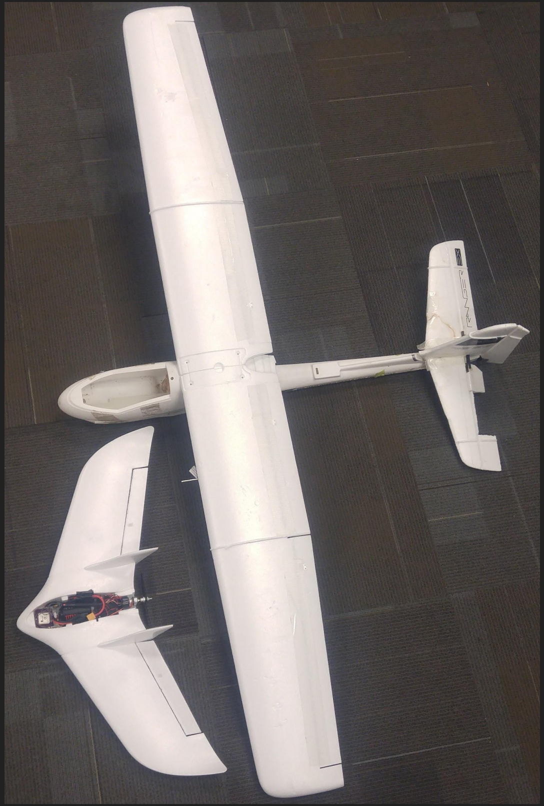
Payload Engineering

Parrot Sequoia

- Multi Spectral
- Light weight system
- Testing Flight Times

Fixed-wing Research Platform



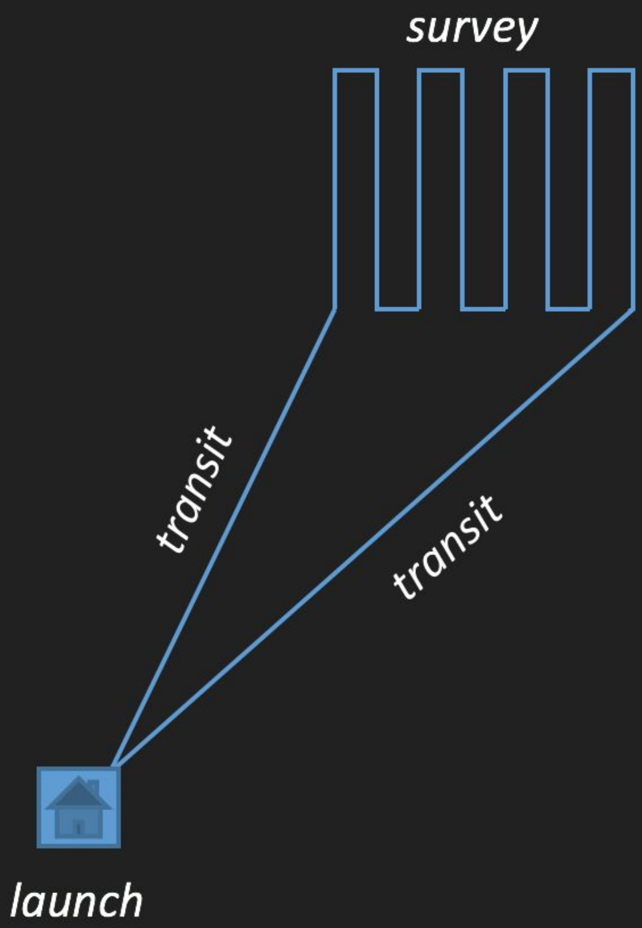


Efficiency Improvement

Lane width:	20 - 100m
Survey grid:	100 - 1000m (side length)
Transit length:	0 - 2000m

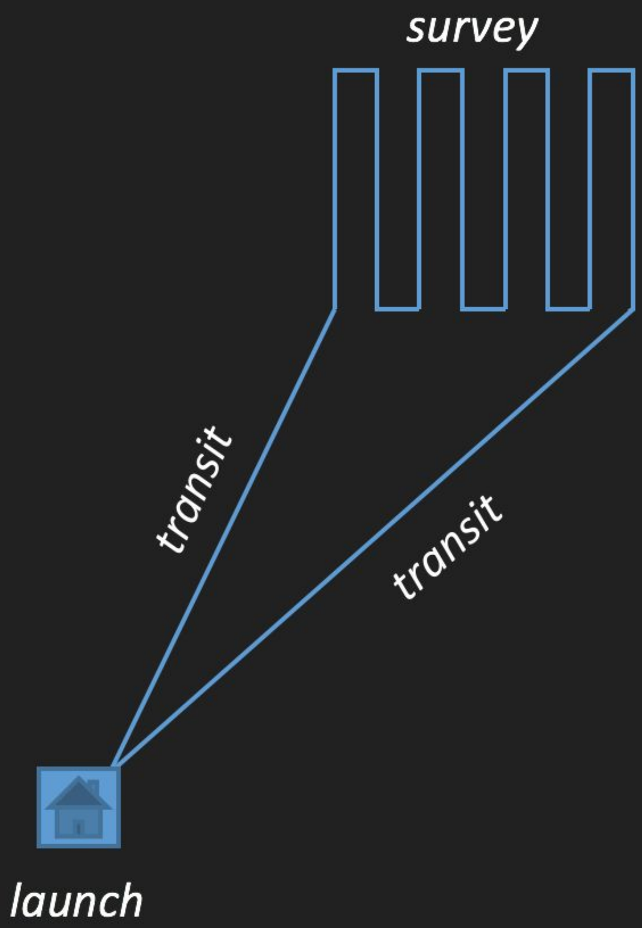
Phantom speed: ~7 m/s

Wing Wing speed: ~14 m/s



Efficiency Improvement

	Scenario 1	Scenario 2
Lane Width	30m	25m
Survey Grid	300x300m	500x500m
Survey Distance	3.3km	15km
Transit Length	0km	1km
Phantom Time	8 min	56 min
Wing Wing Time	4 min	18 min



Radio Collar Project

Kati Dahn
Anthony Koutroulis

UC San Diego ENGINEERS FOR EXPLORATION

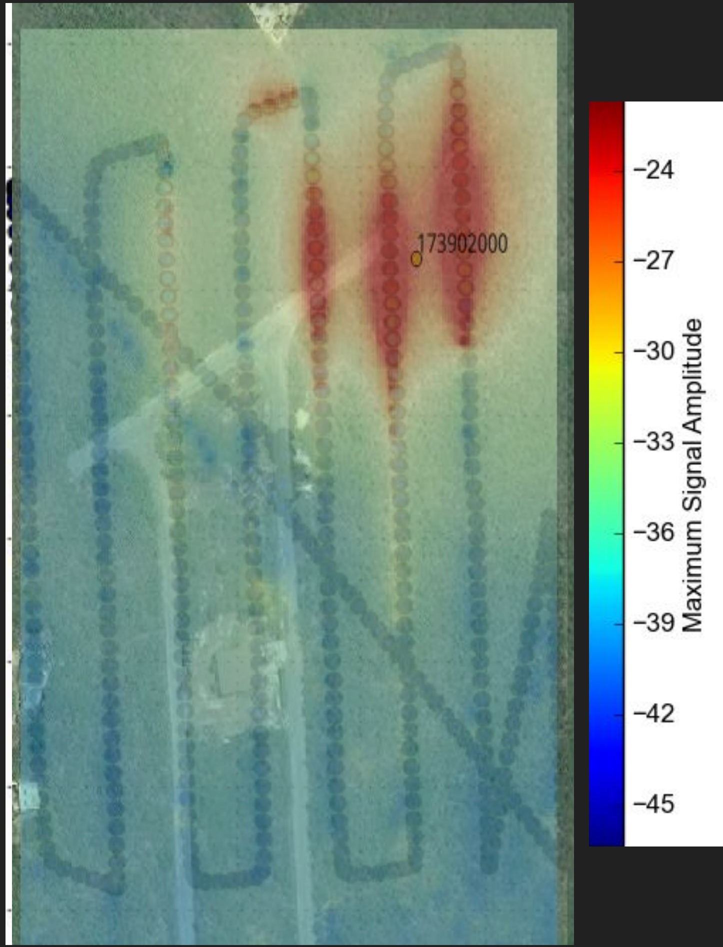
SAN DIEGO ZOO INSTITUTE FOR CONSERVATION RESEARCH

Airborne Radio Telemetry

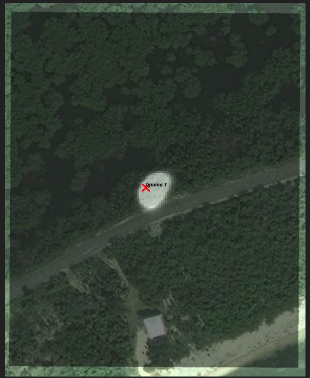
Drone - 3DR SOLO

Tracking Iguanas in the Cayman Islands

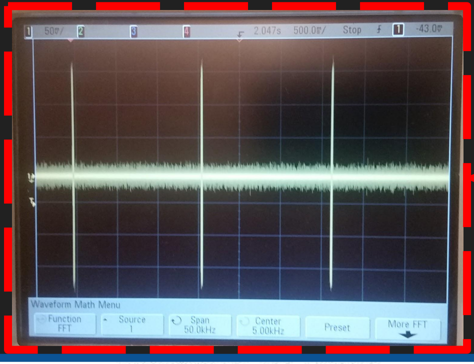
E4E Tracking Method



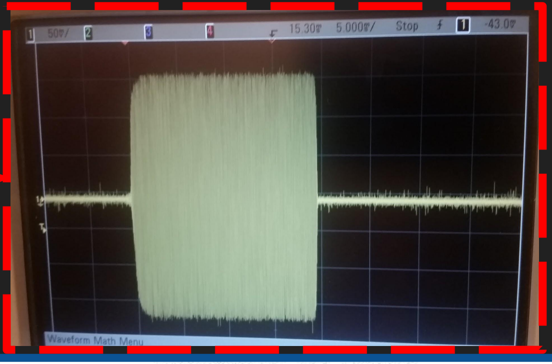
2017 Expedition

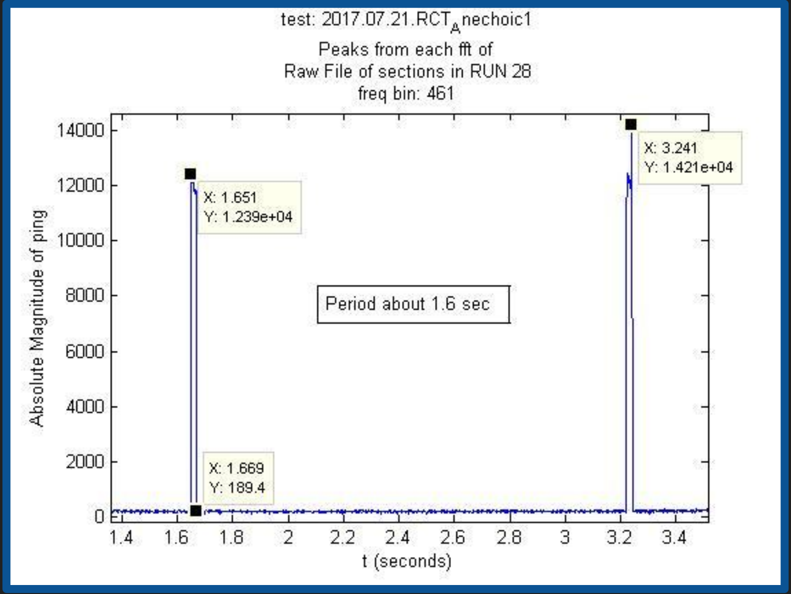


New Collar Profile

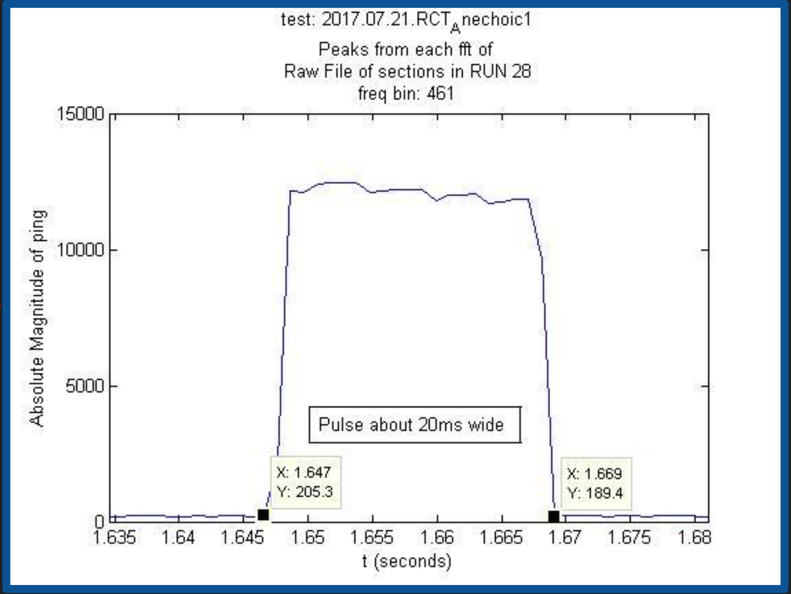


Scope

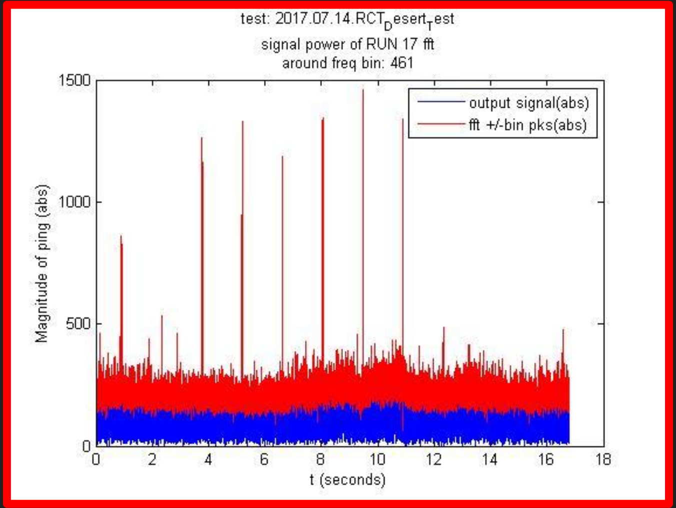


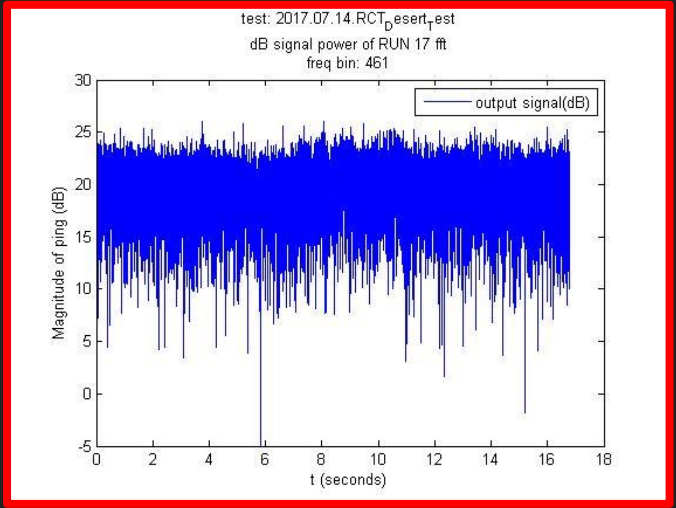


Matlab
IF
signal

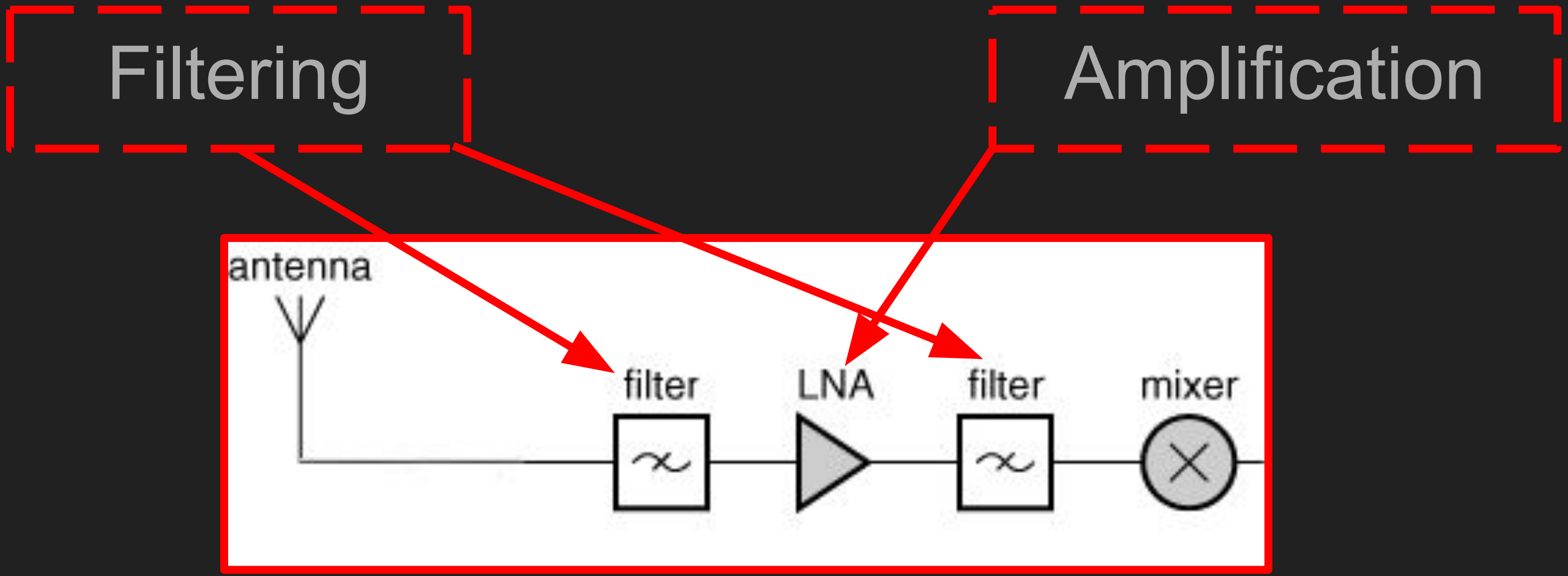


Field Tests for signal strength

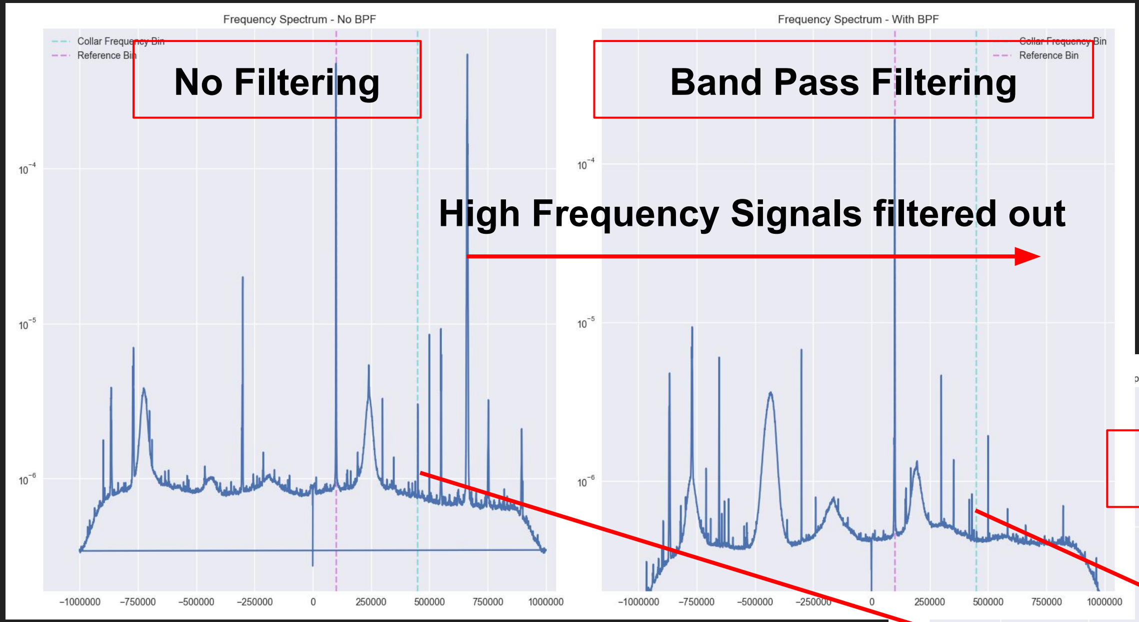


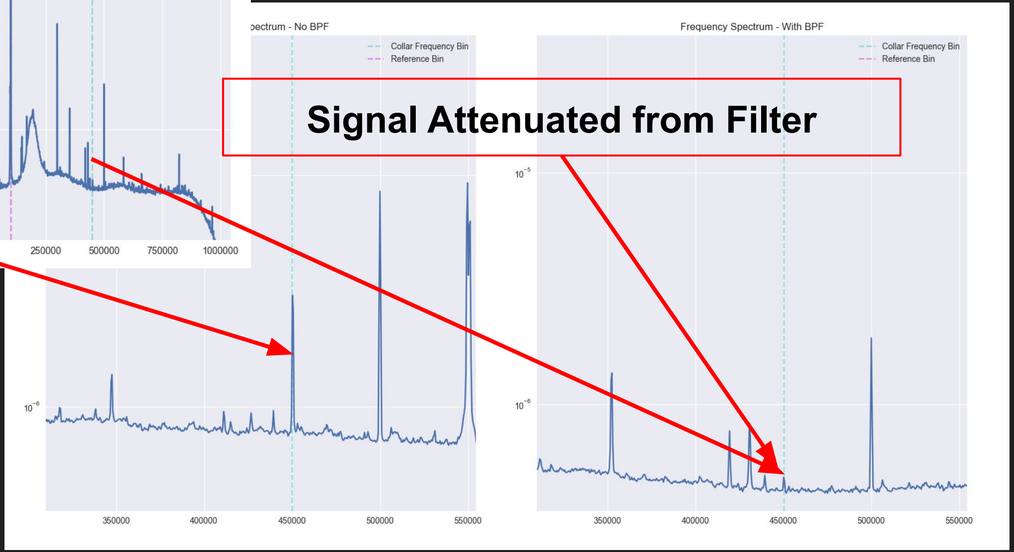


Need to be more selective

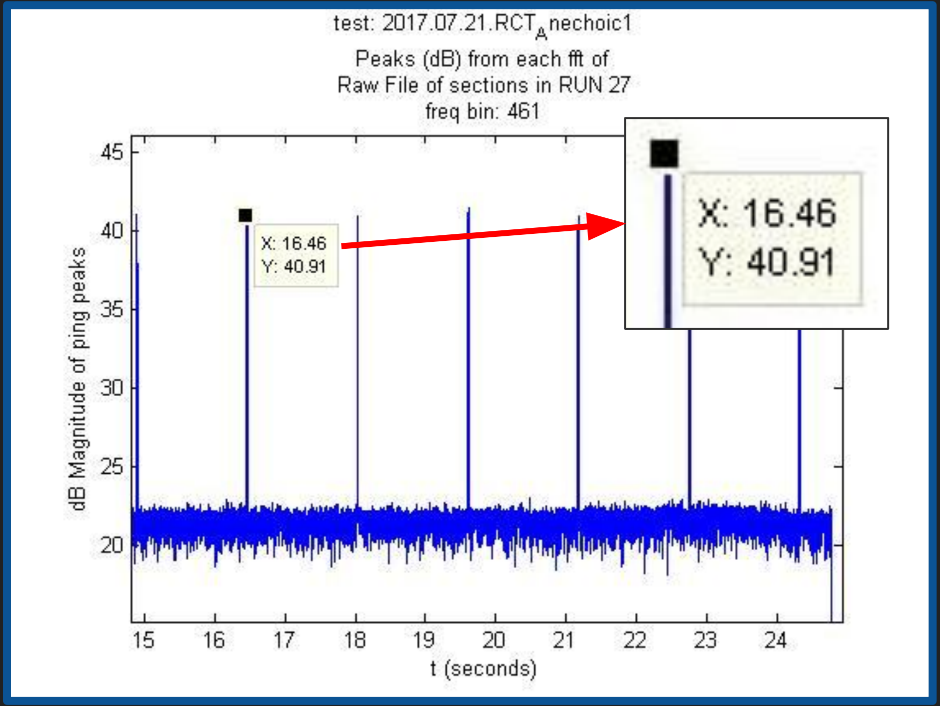


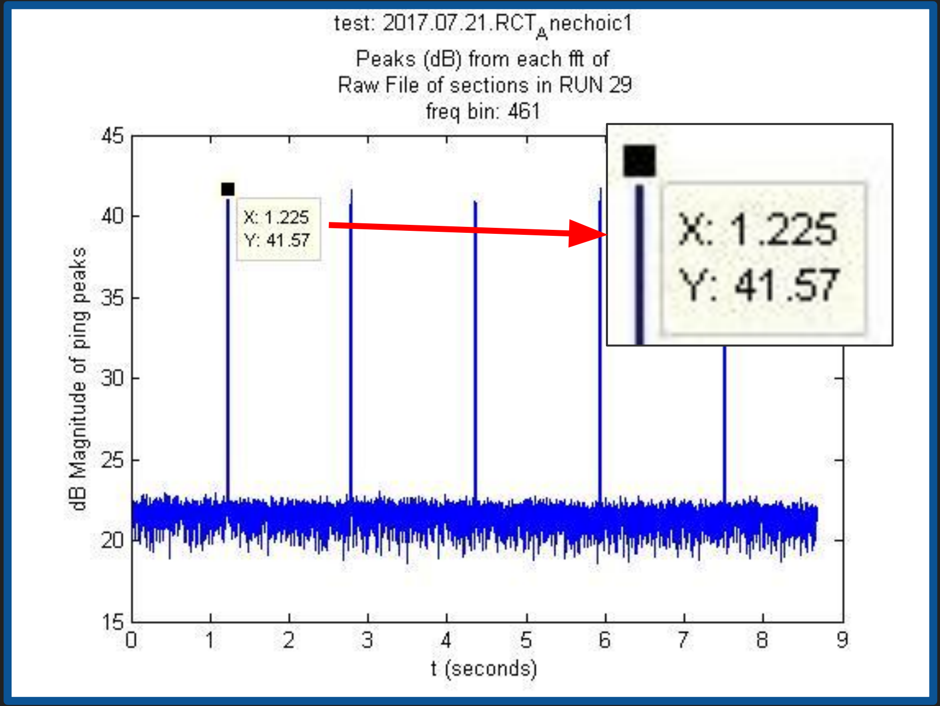
Results from Filtering





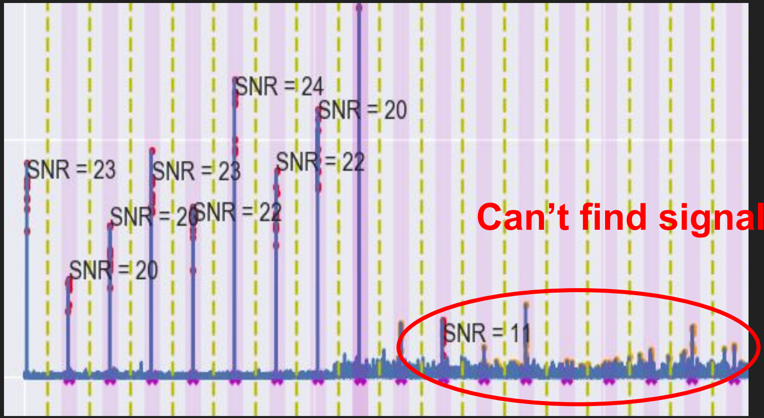
Results from Amplification





Still need more.

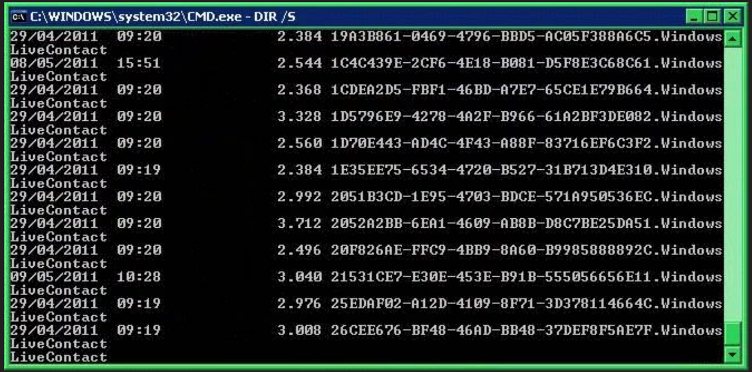
Signal Processing Challenges



Automatic detection failures

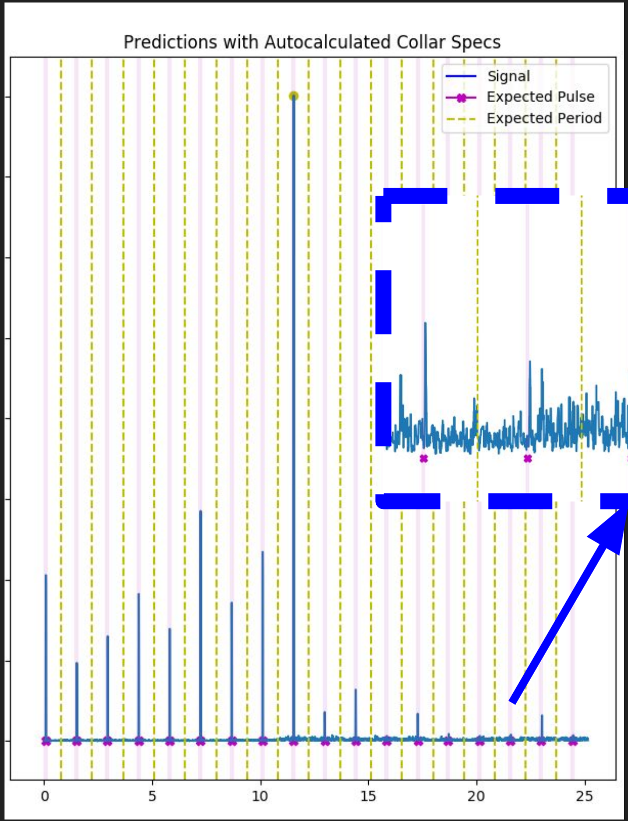
➔ Requires locating collars manually

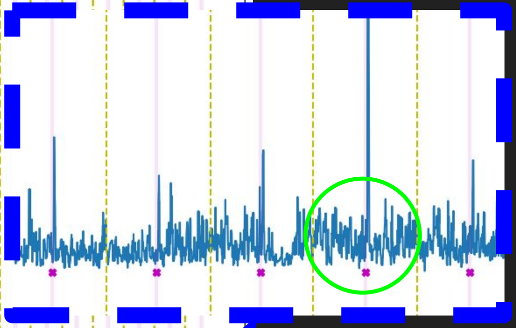
Difficult to use detection scripts



Algorithms for Automatic Detection

Predictions and Detections

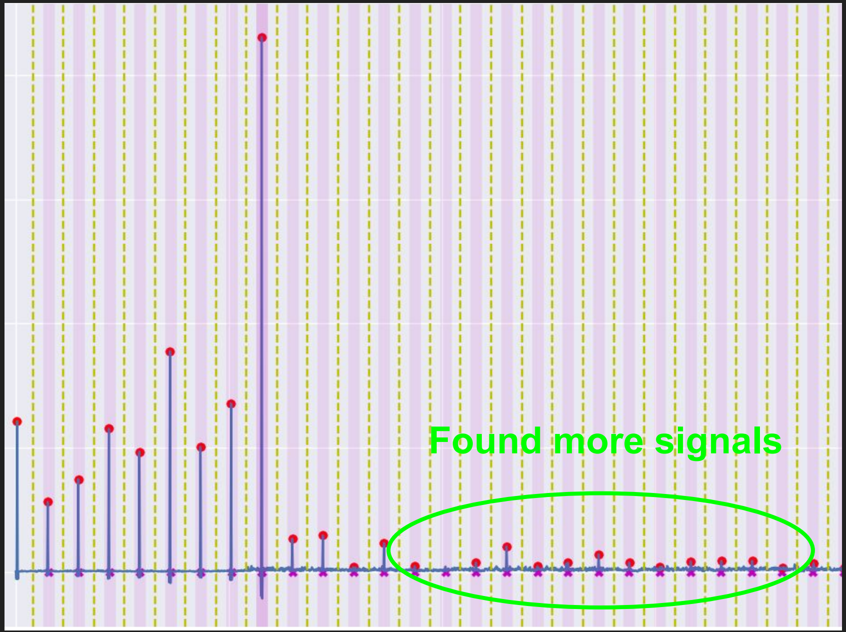




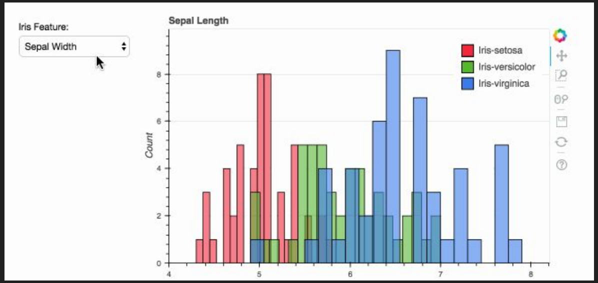
Predict ping positions

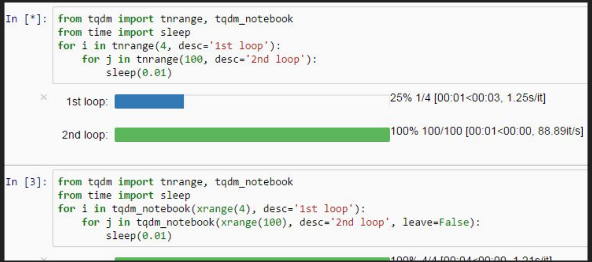
Improve predictions,

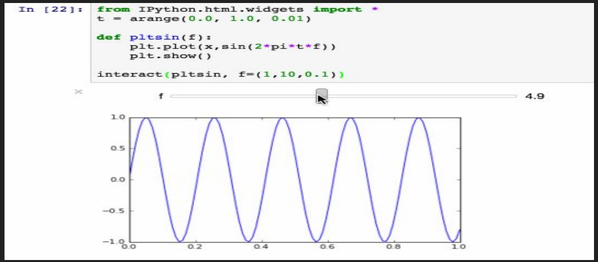
Improve detections.

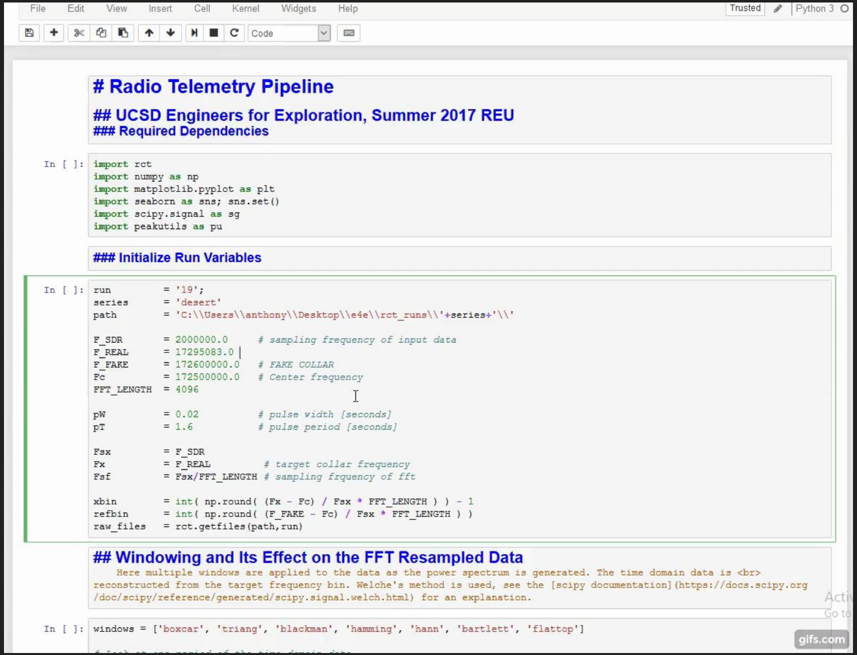


Engineering a Pipeline



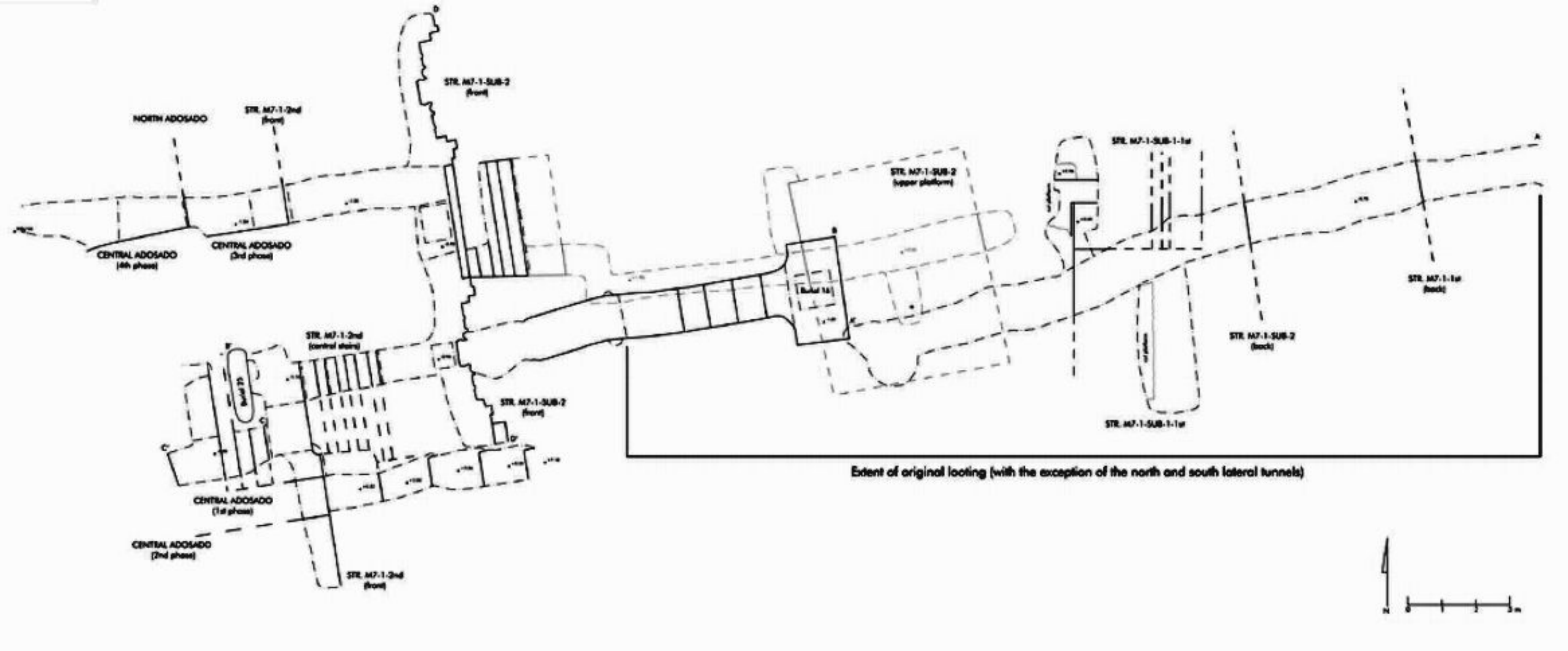






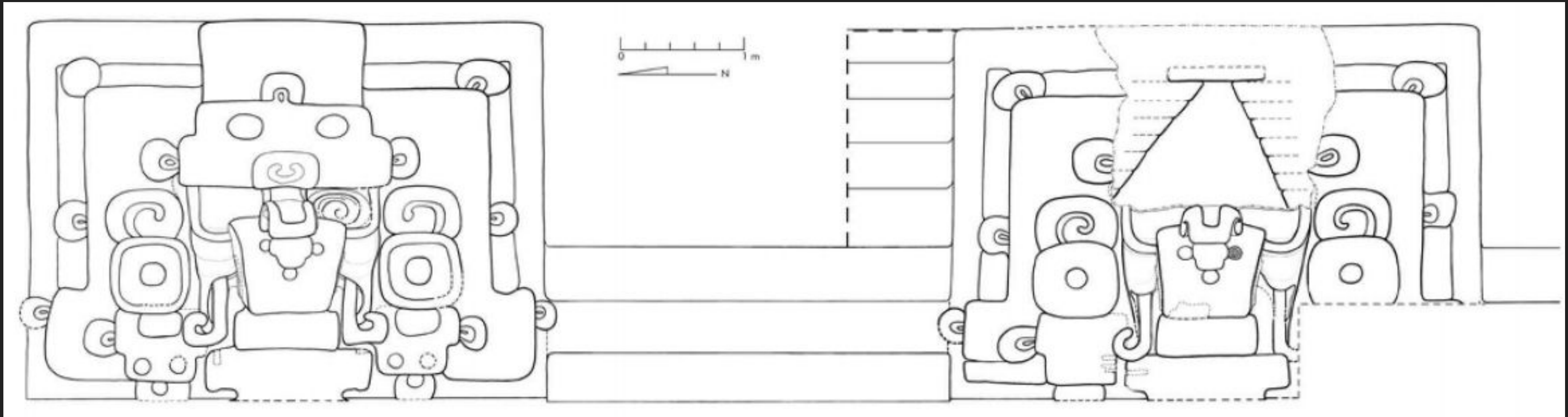
Maya Archaeology

Proud Heng Waseem Khan Danbing Zhu



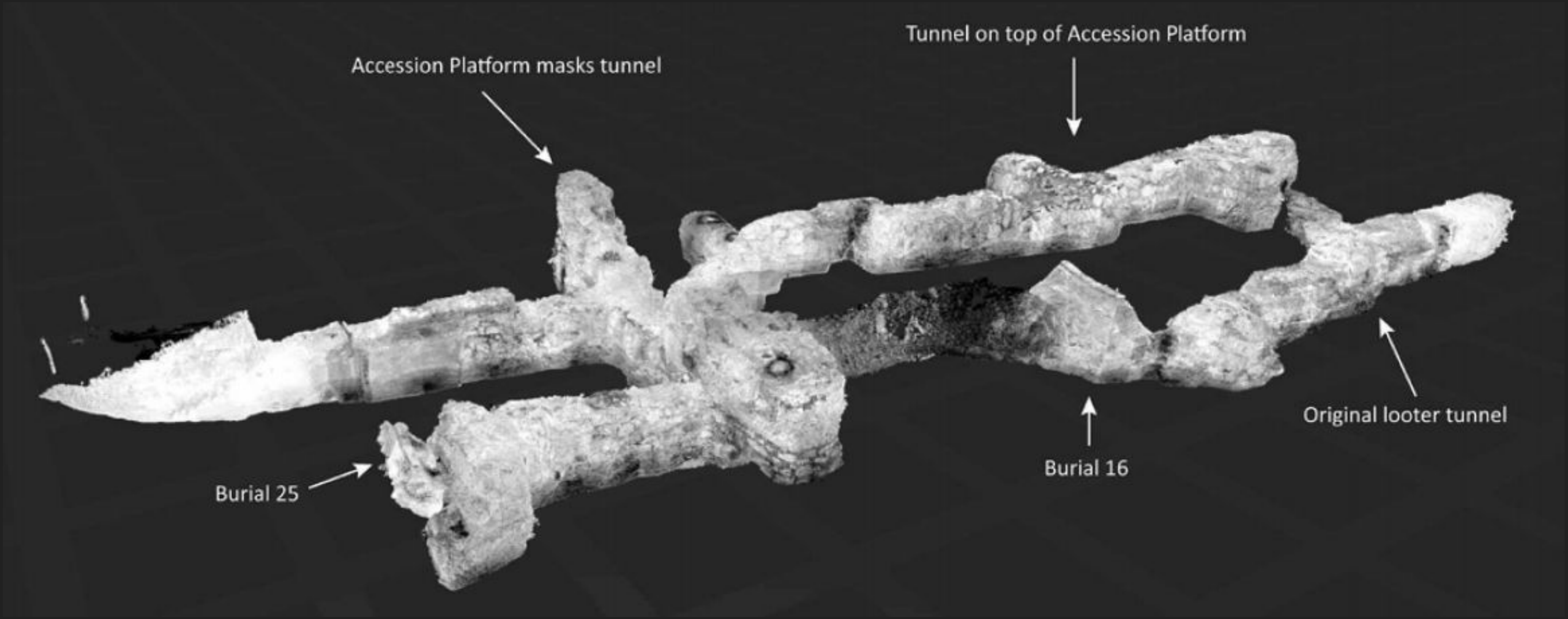
El Zotz Structure M7-1 ("Pyramid of the Wooden Lintel")

Plan of the Str. M7-1 tunnel excavations



Profile drawing of the front
of the excavated portion of the Accession Platform

What if we generated 3D computer models?



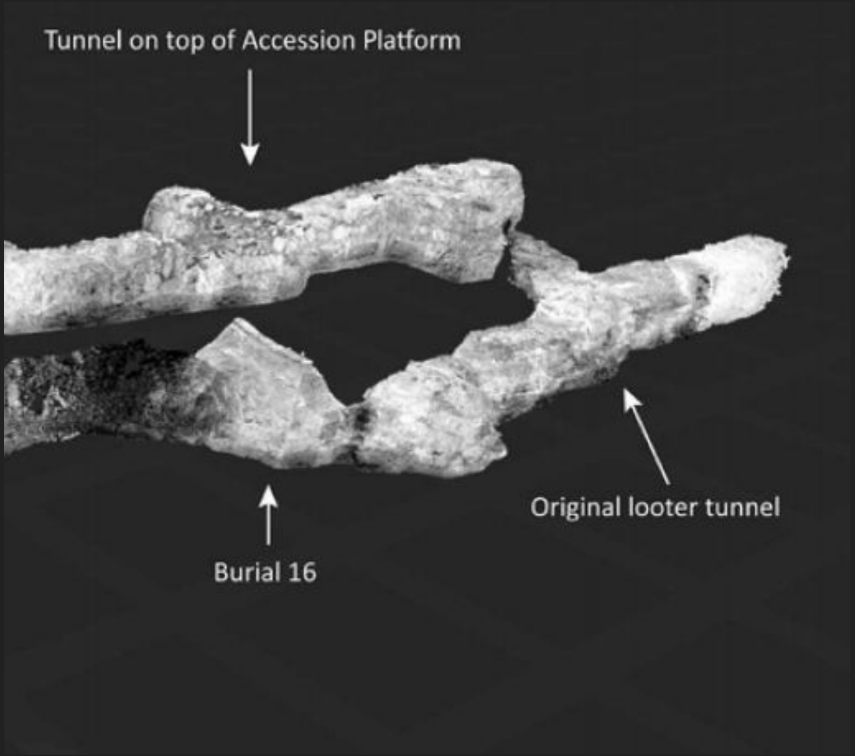
Thomas G. Garrison, Dustin Richmond, Perry Naughton, Eric Lo, Sabrina Trinh, Zachary Barnes, Albert Lin, Curt Schurgers, Ryan Kastner, and Sarah E. Newman, “**Tunnel Vision: Documenting Excavations in Three Dimensions with Lidar Technology**“, Advances in Archaeological Practice, Volume 4, Number 2, May 2016, pp. 192-204(13)

Goals for 3D reconstruction

1. Accurate
2. Portable
3. Gets real-time results
4. Affordable
5. Simple to use
6. Quick

Reconstructing 3D computer models

Light Detection and Ranging (LiDAR)



Reconstructing 3D computer models

Light Detection and Ranging (LiDAR)

- \+ Accurate
- \- Bulky
- \- Results are not real-time
- \- Expensive
- \- Time-consuming

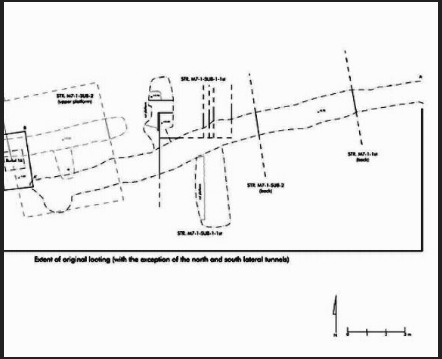
Reconstructing 3D computer models

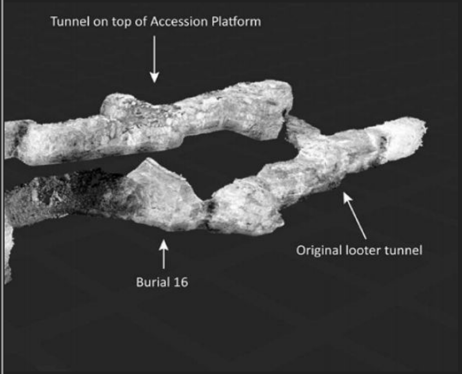
Structure from Motion (SfM)

Reconstructing 3D computer models

Structure from Motion (SfM)

- \- Is it accurate?
- \+ Portable
- \- Results are not real-time
- \+ Affordable
- \+ Quick





	Traditional Sketch	Lidar scan	Structure from Motion
Accurate	?	Y	?
Portable	Y	N	Y
Gets real-time results	Y	N	N
Affordable	Y	N	Y
Simple to use	N	N	Y
Quick	N	N	Y

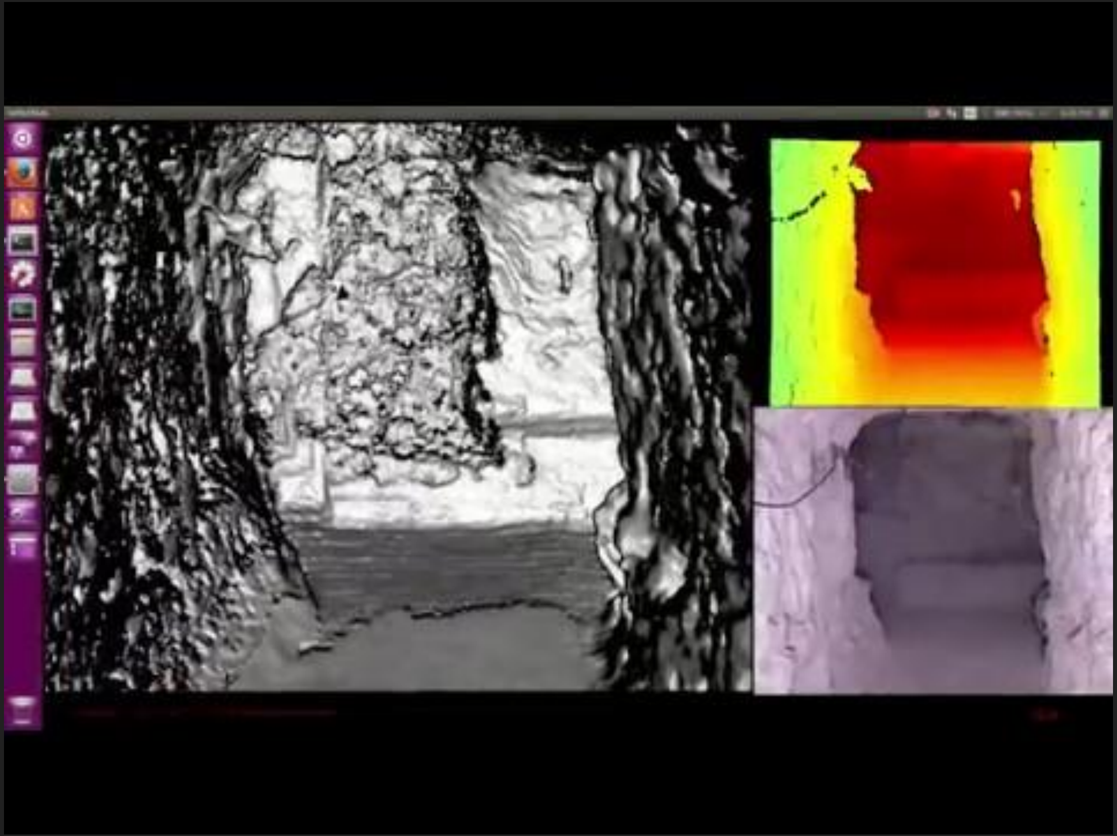
Simultaneous Localization and Mapping (SLAM)

Reconstructing 3D computer models

Simultaneous Localization and Mapping (SLAM)

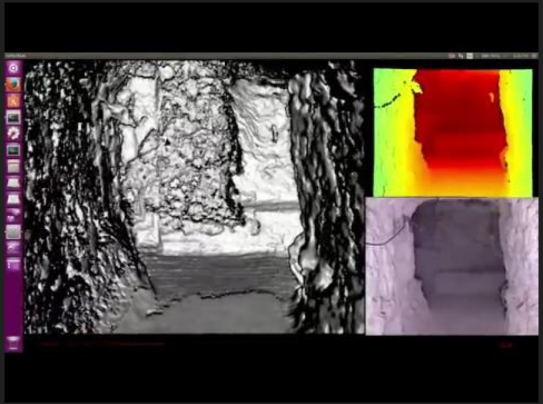
- \- Is it accurate?
- \+ Portable
- \+ Real-time results
- \+ Affordable
- \+ Quick

SLAM Algorithm (InfiniTAM)



Comparing SLAM algorithms

InfiniTAM

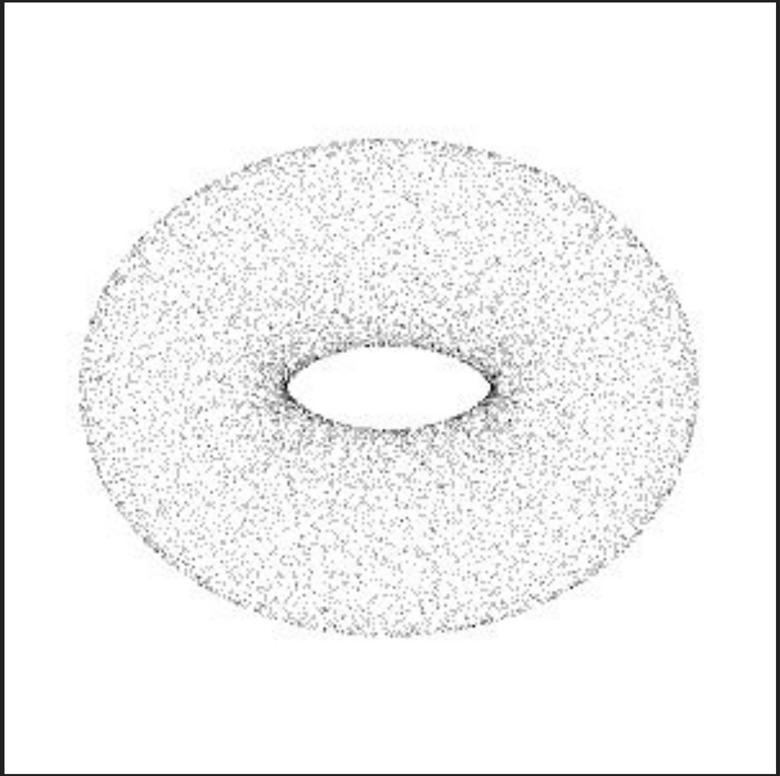


ORB SLAM2

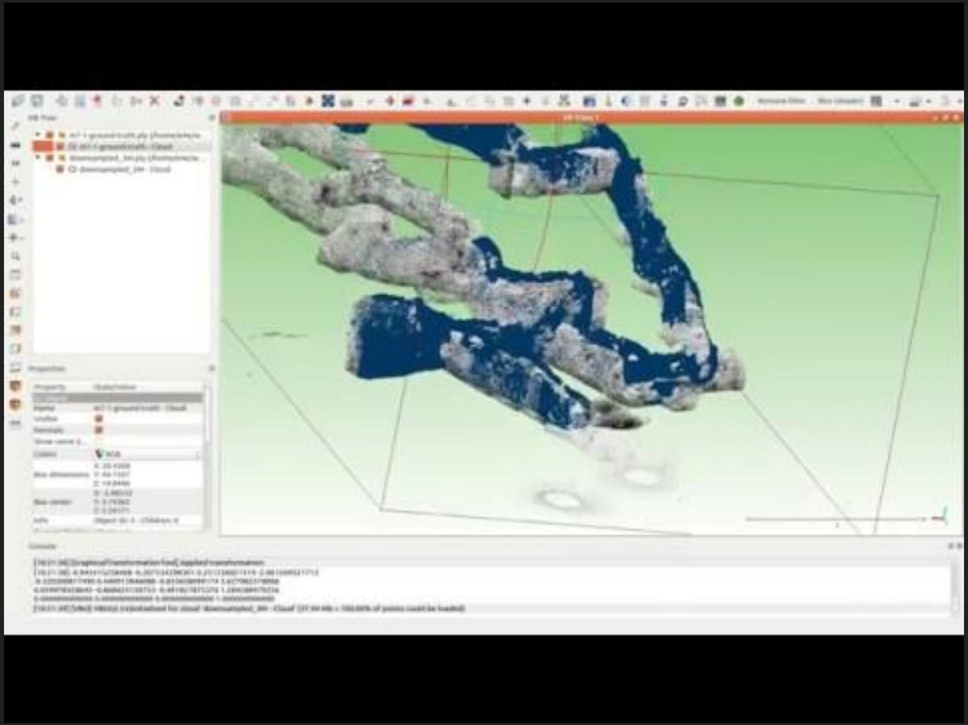
RGBD SLAM

RTABMAP

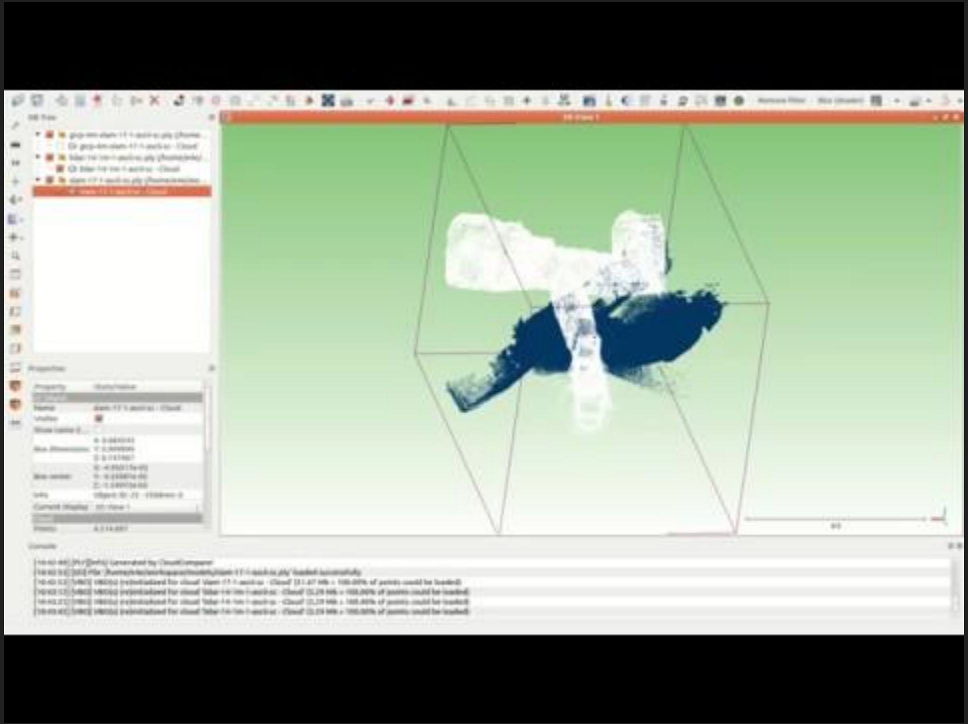
What is a point cloud?



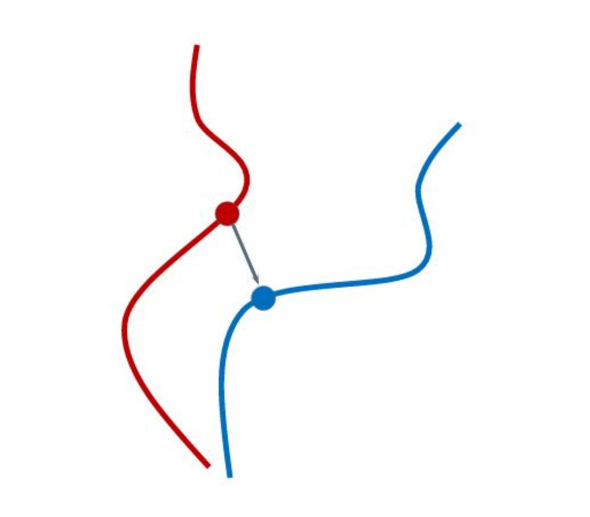
SLAM to LIDAR Ground Truth

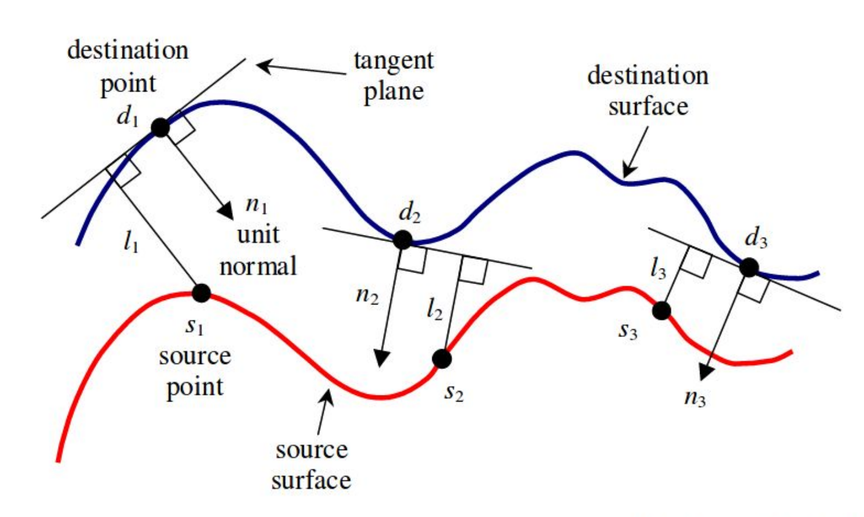


Point Cloud Registration



Error Metrics (point to point, point to plane)



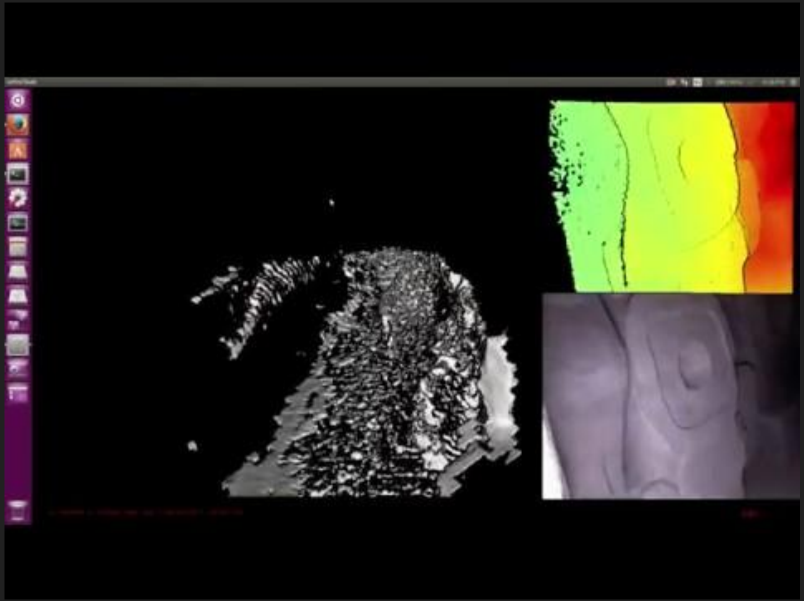


Point to Plane Error Results

Tunnel name	RTABMAP (p2pl)	ORBSLAM (p2pl)	INFINITAM (p2p)
M7-1(entrance)	0.341261	lost track	1.057848
M7-1(first junction)	0.407281	0.735962	1.409410
M7-1(right mask)	0.206746	0.192900	0.251941
M7-1(stairs)	0.655518	0.525535	lost track
M7-1(upstairs)	0.229581	0.269485	0.208416
M7-1(excavation)	0.153848	no lidar data	0.444810

Future work

- How can we keep SLAM from losing track of where it is?
- Can we merge different SLAM algorithm results?
- How close are real-time SLAM results to post-processed results?



Thank You