SAV Remote sensing workshop

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Goals for workshop

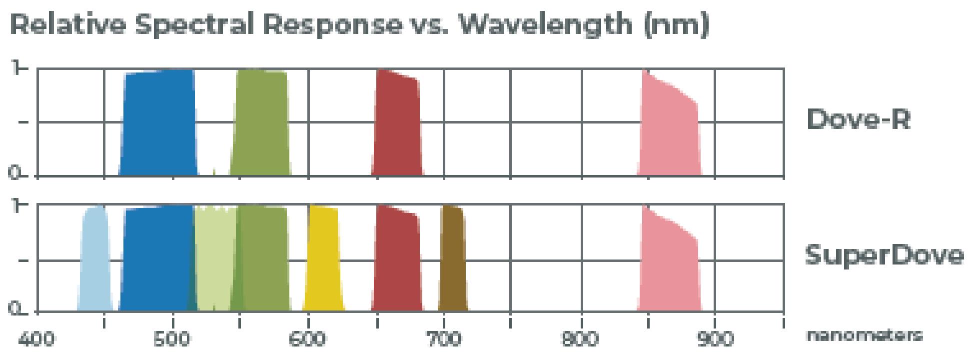
- Discuss our methodology and processing workflow
- Search PlanetScope for coverage of your region
- Learn how to classify your images to SAV presence/absence
- Learn how to use Python batch processing to semi-automatically process your imagery to seasonal/annual maps
- Generate leaf area index and above ground carbon estimates

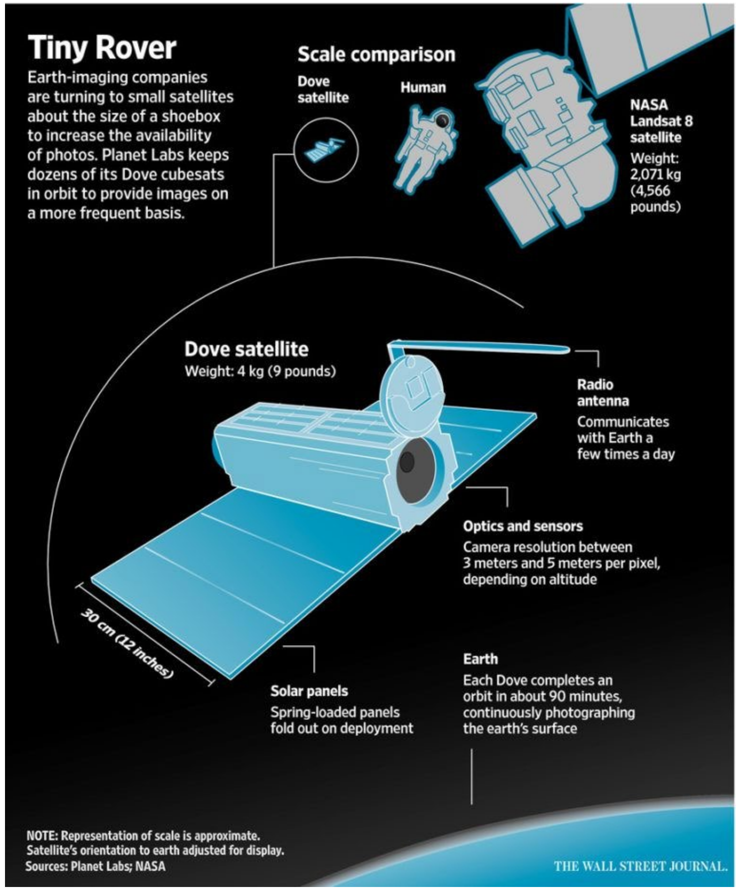
Workshop session 1

- Overview of SAV remote sensing with Planet data
- Current workflow for processing imagery
- Ordering Planet imagery & NOAA DEM data

Planet

- 4 to 8 spectral bands
- Products available include surface reflectance (***atmospheric correction***) and ***harmonized*** (to Sentinel)
- **Dove-R**: 3 m spatial resolution on 4 bands
- **SuperDove**: 3 m spatial resolution on 8 bands
- ***No tasking***, land and coastlines imaged everyday
- Archive starts 2016
- Almost daily coverage of land and coastlines
- Data open for academic research, federally funded projects, and through the European space agency
- **Proven success in using these sensors for seagrass mapping.**

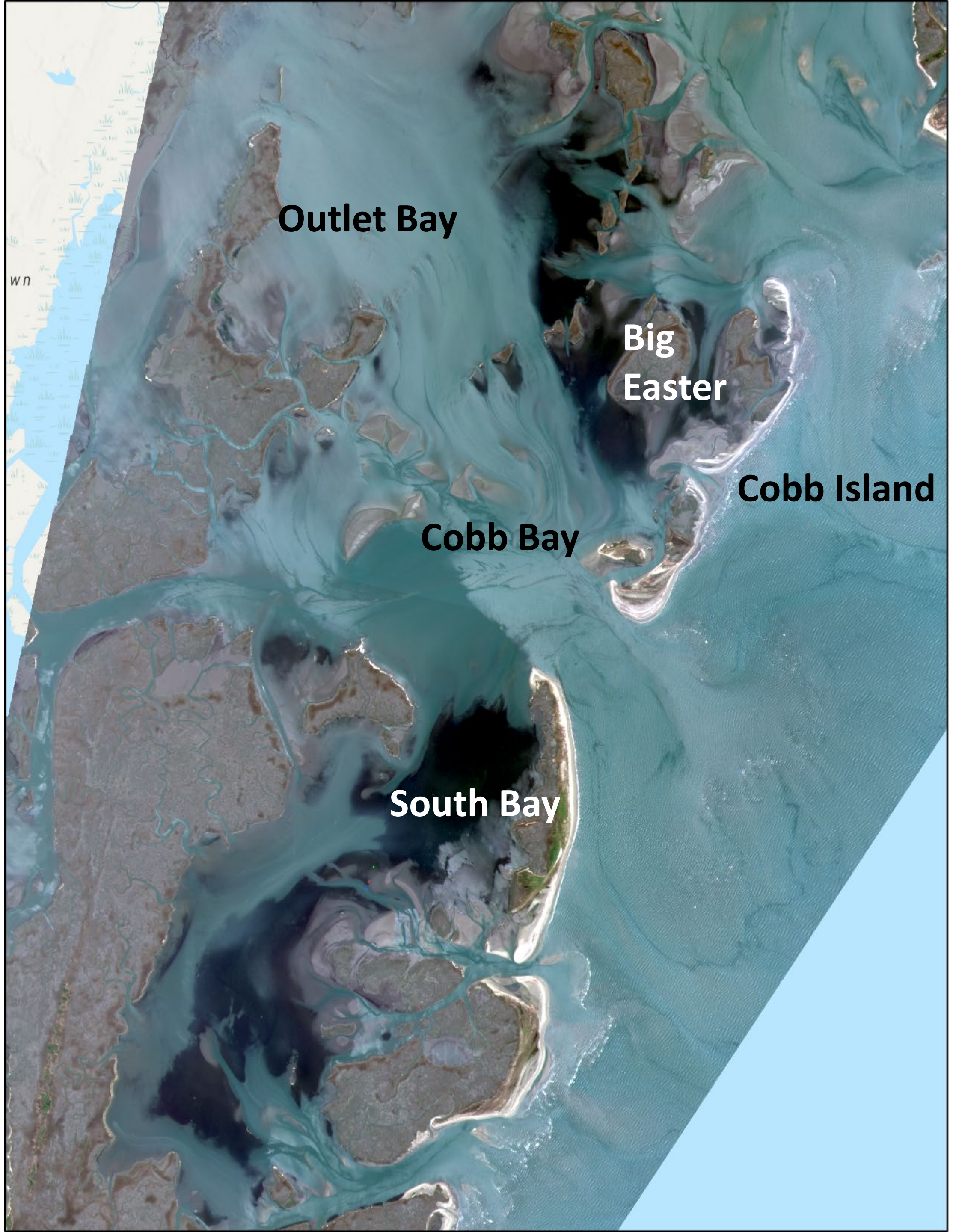




South Bay & Spider Crab

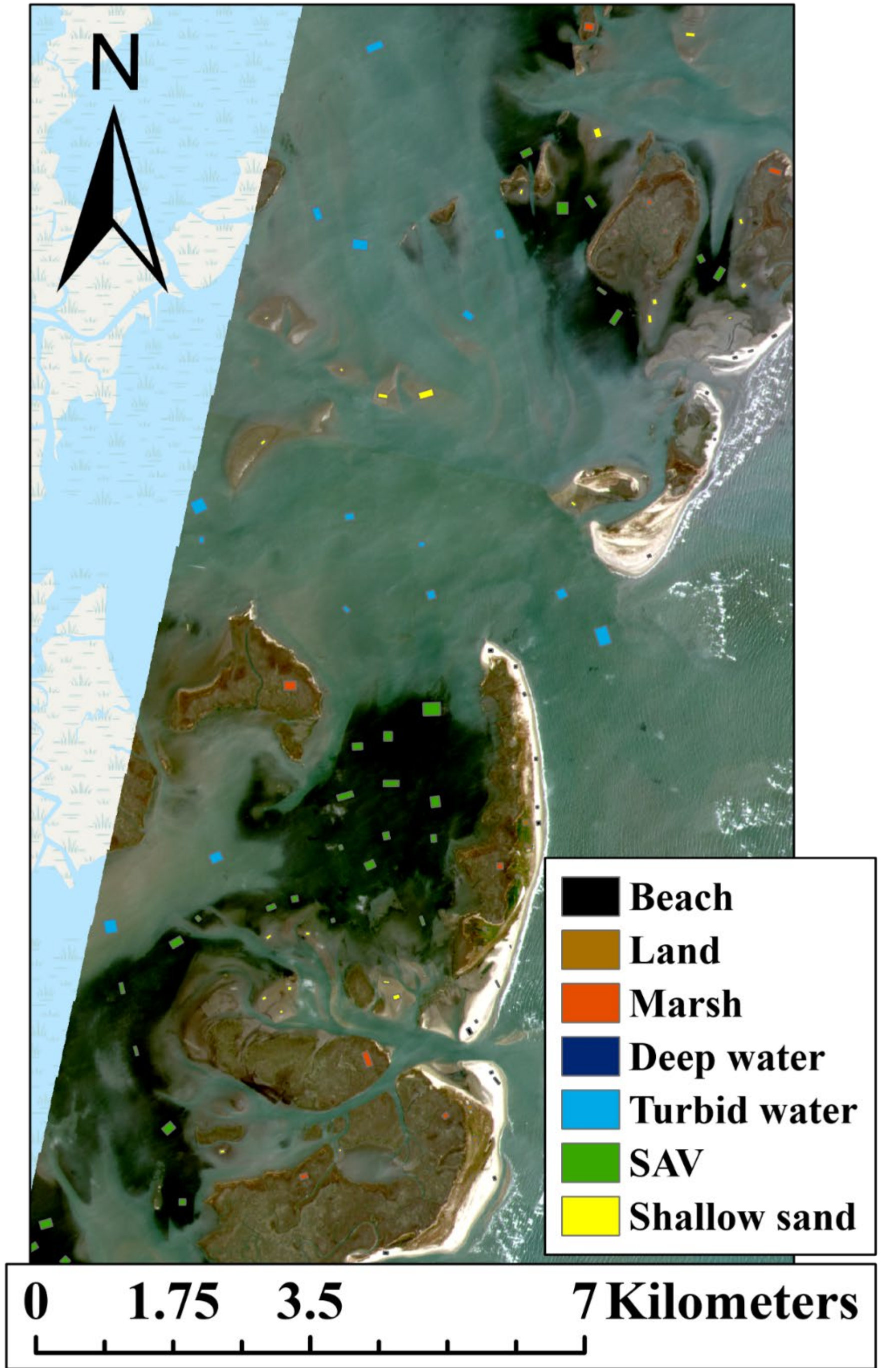
- Planet passes every day, often multiple passes from different sensors.
- Images good for seagrass identification.
  - Low tide
  - Low turbidity
  - Low cloud cover.

Year	Jan-Mar	April-June	July-Sept	Oct-Dec	Total
2018	1	3	3	1	8
2019	2	1	7	2	12
2020	0	5	5	1	11
2021	2	7	7	2	18
2022	0	4	6	4	14



Classification

- Supervised classification
- Regional expert identified training patches
- Each individual image is classified



Classification

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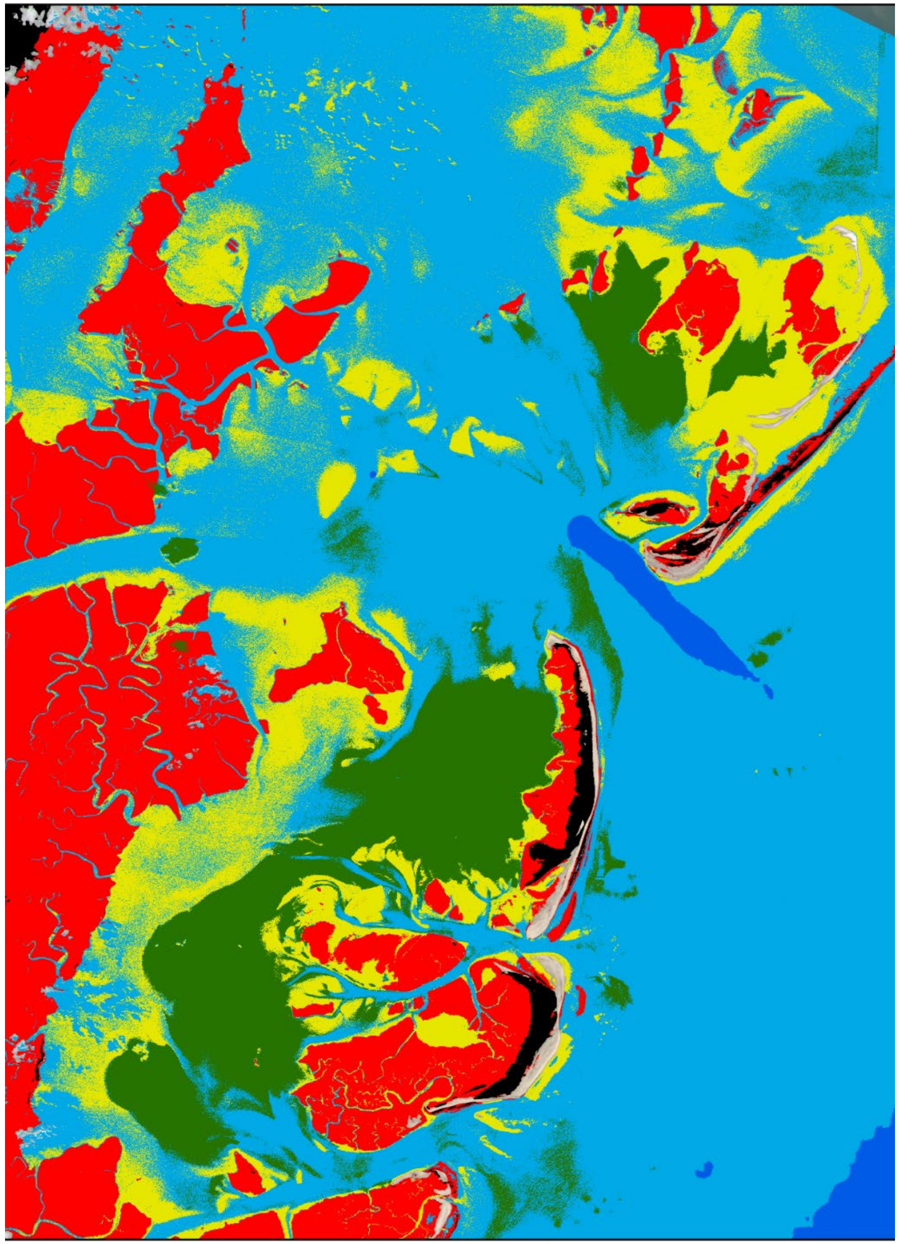
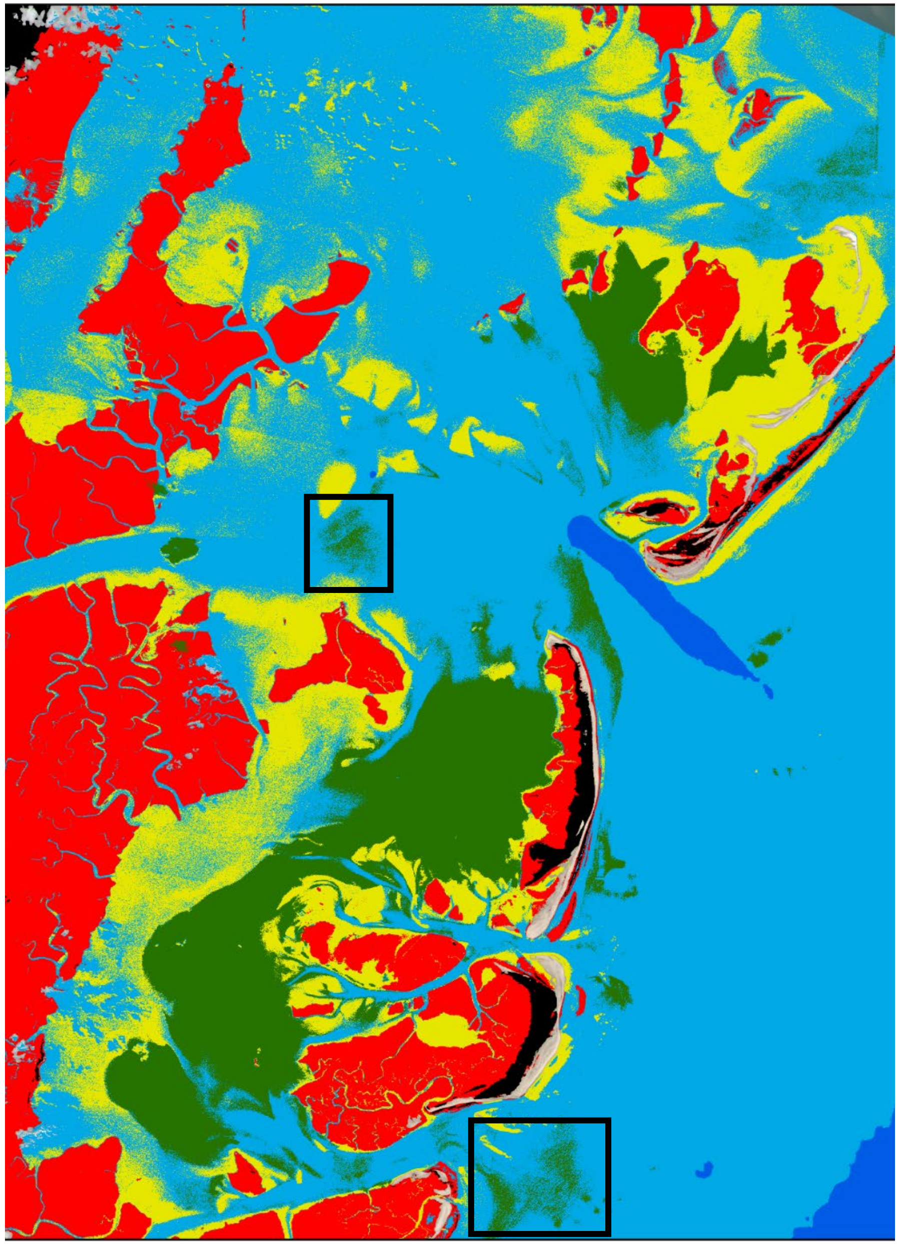
- Each individual image is classified
- There will always be misclassifications



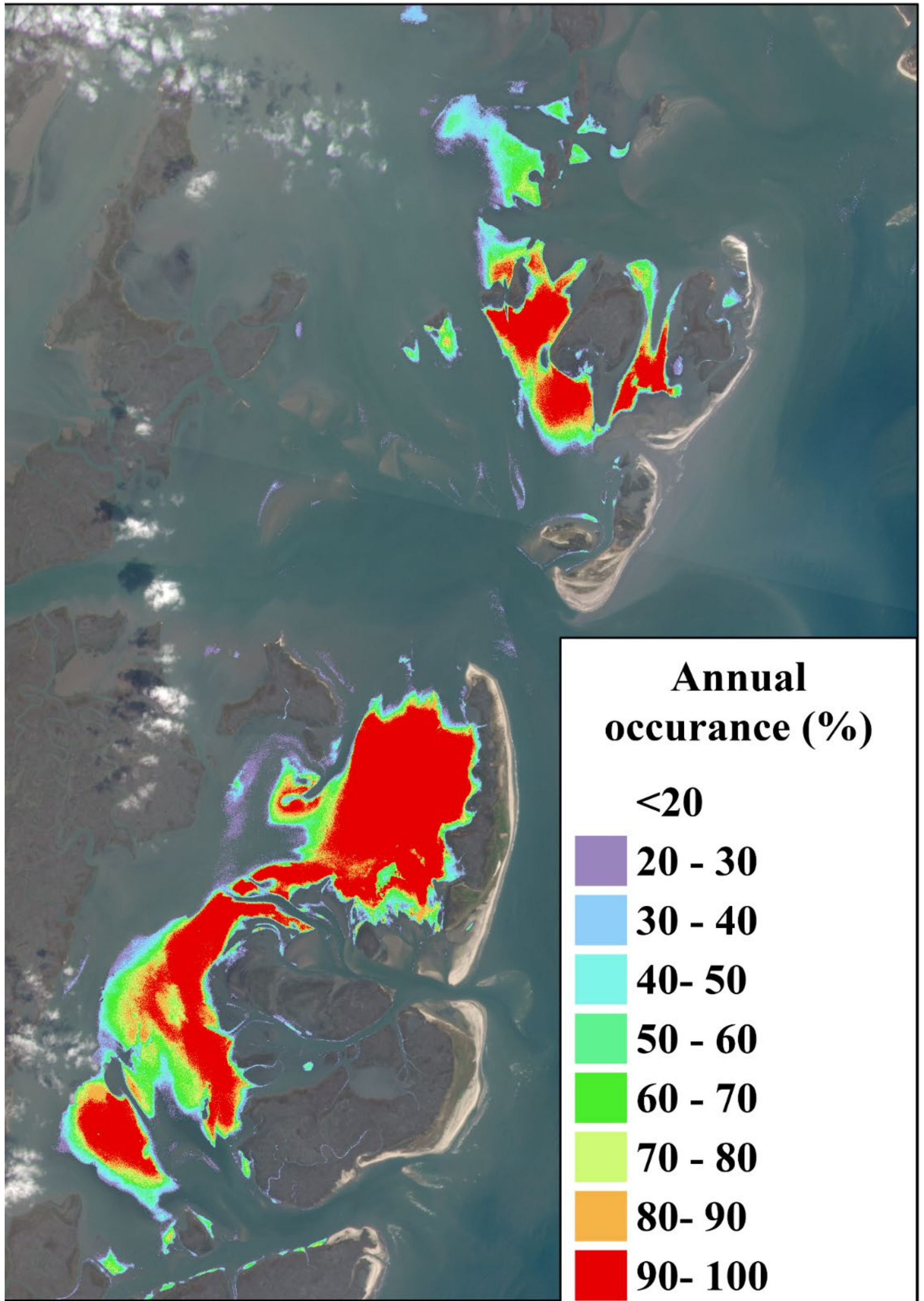
Classification

- Supervised classification
- Regional expert identified training patches
- Each individual image is classified
- There will always be misclassifications
  - Optically deep water can be as green as SAV.
  - We solved some of this by adding in water depth as a factor in the classification.
  - Misclassified pixels are generally not the same location in each image.



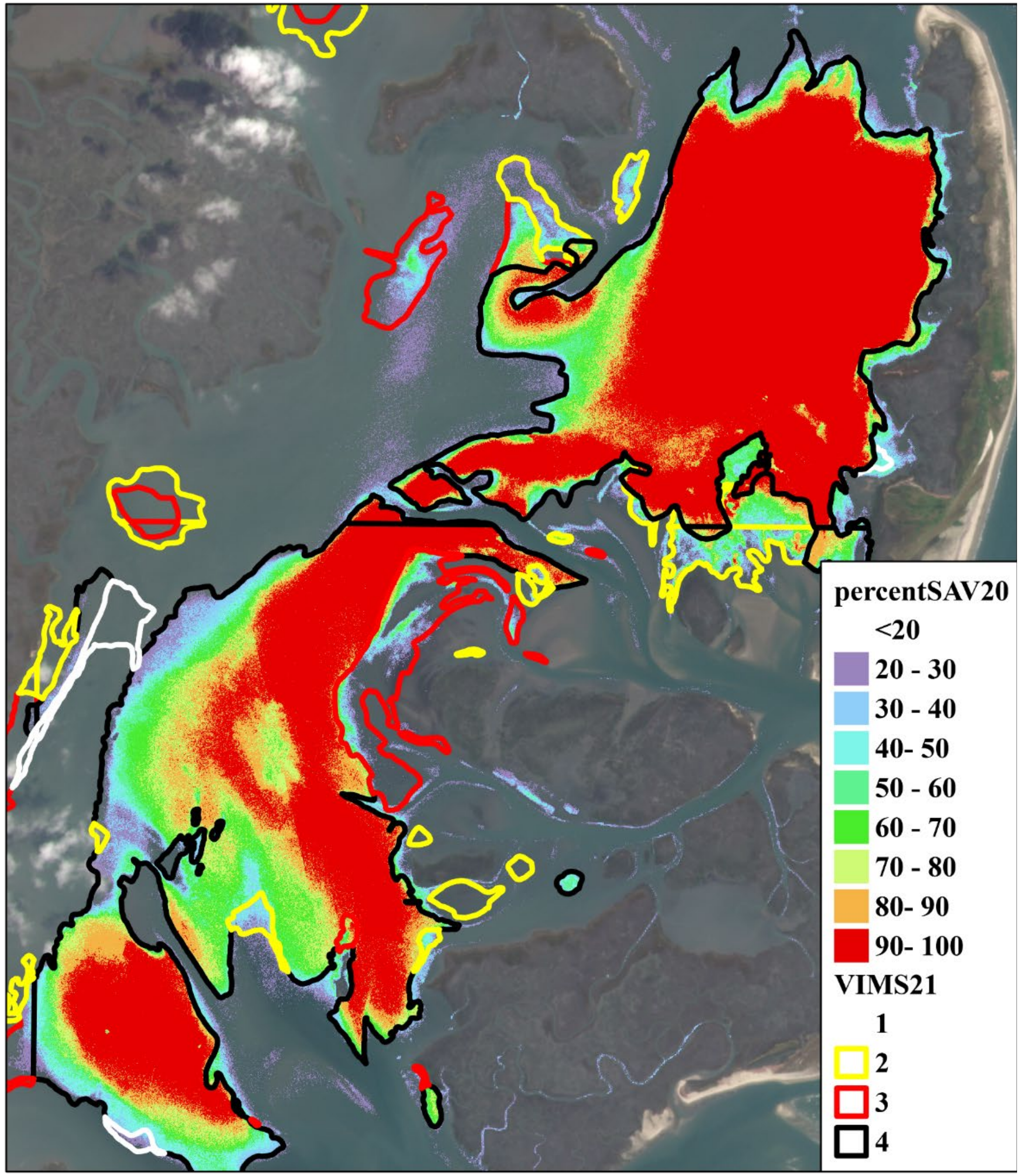
Frequency presence

- Use the power of having multiple images of your study site to remove misclassifications and identify which locations have a high confidence of SAV.
- Calculate the percent frequency with which each pixel was identified as seagrass.
- Some areas have very low frequency of seagrass presence, probably misclassifications
- Set a threshold for frequency presence.
  - Pixels with frequency less than 20% are set to null.



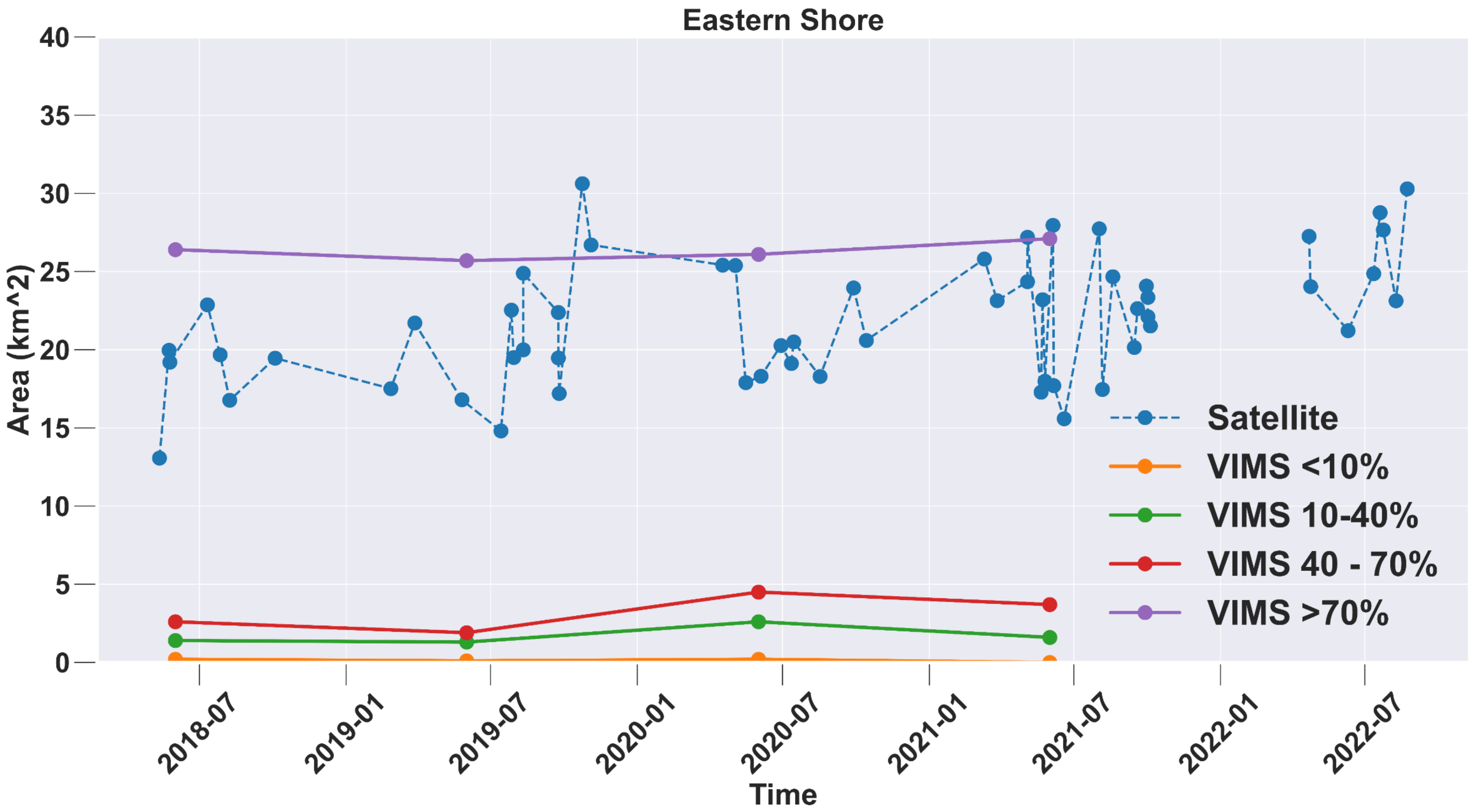
Frequency presence

- Good agreement with the VIMS aerial estimates.



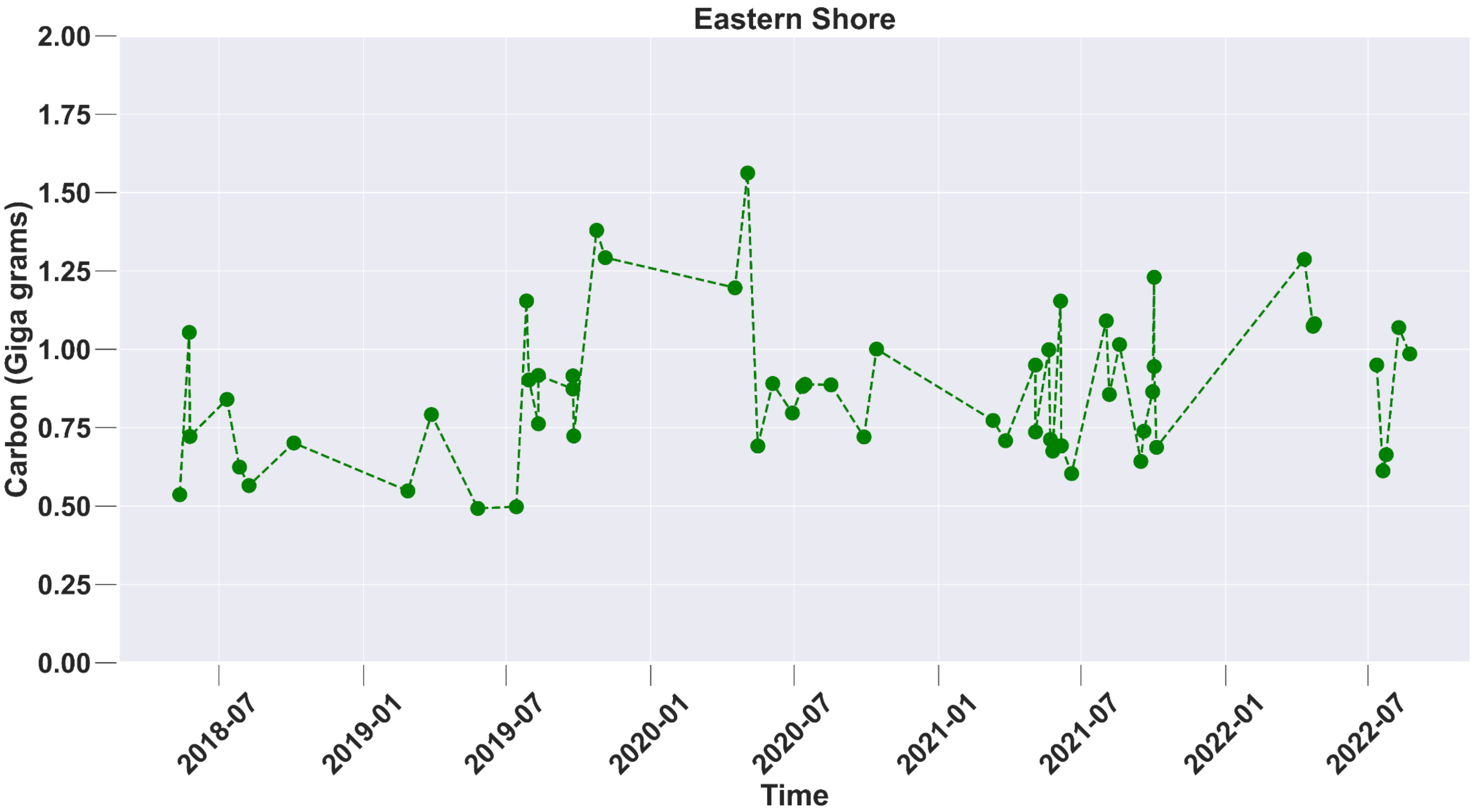
Total SAV area:

Compare pixel based and polygon based approach



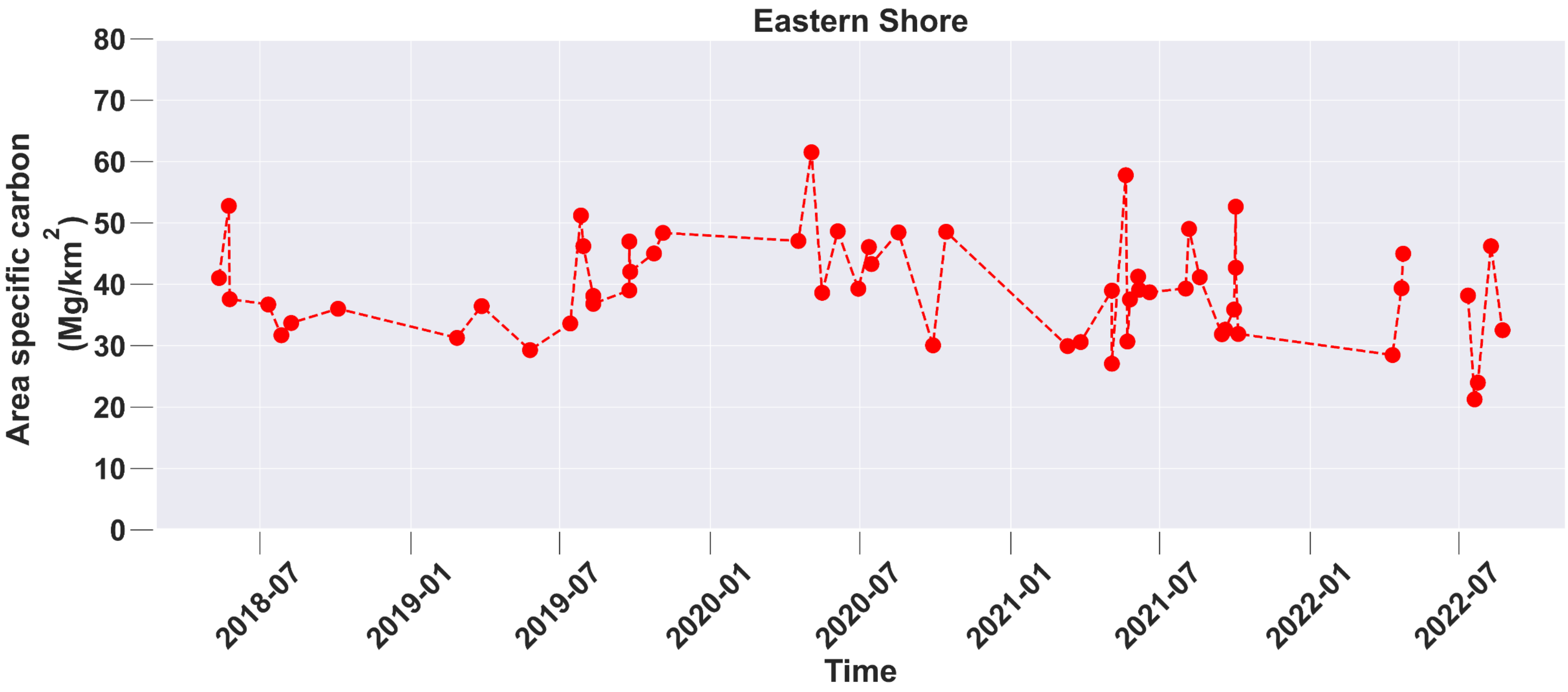
Total above ground carbon

Differences in carbon is due to variation in SAV area.

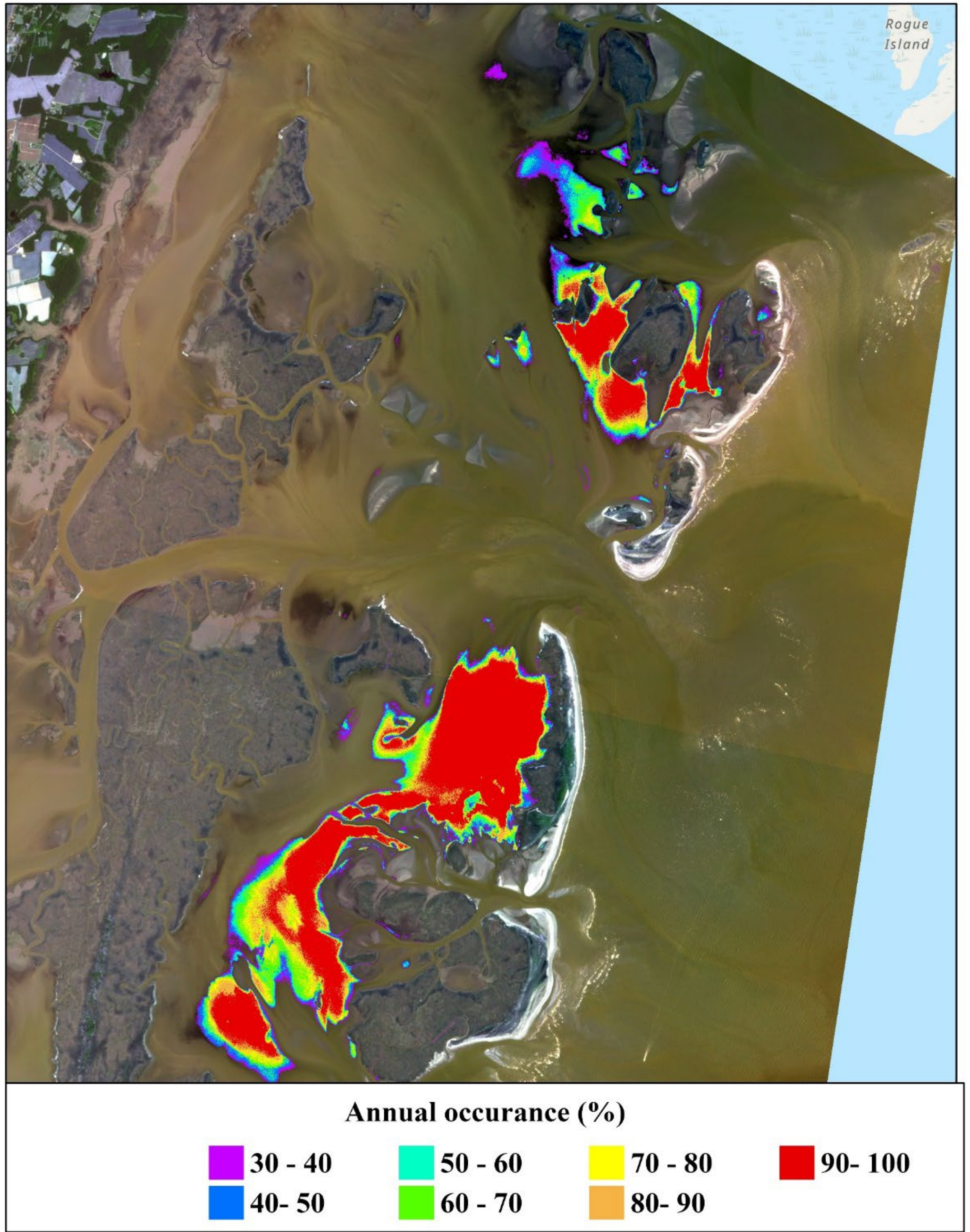


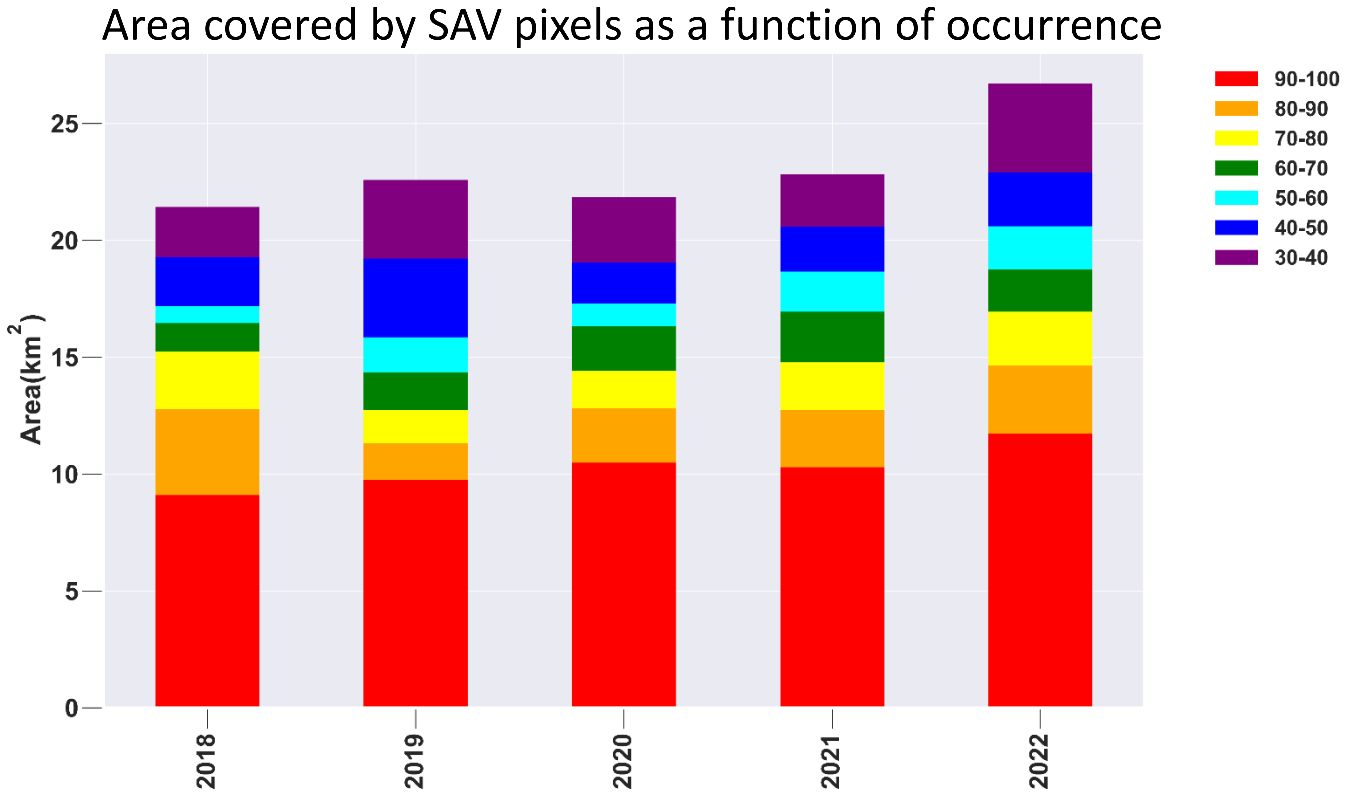
Area specific carbon

Average density of the beds 39.5 Mg km^2

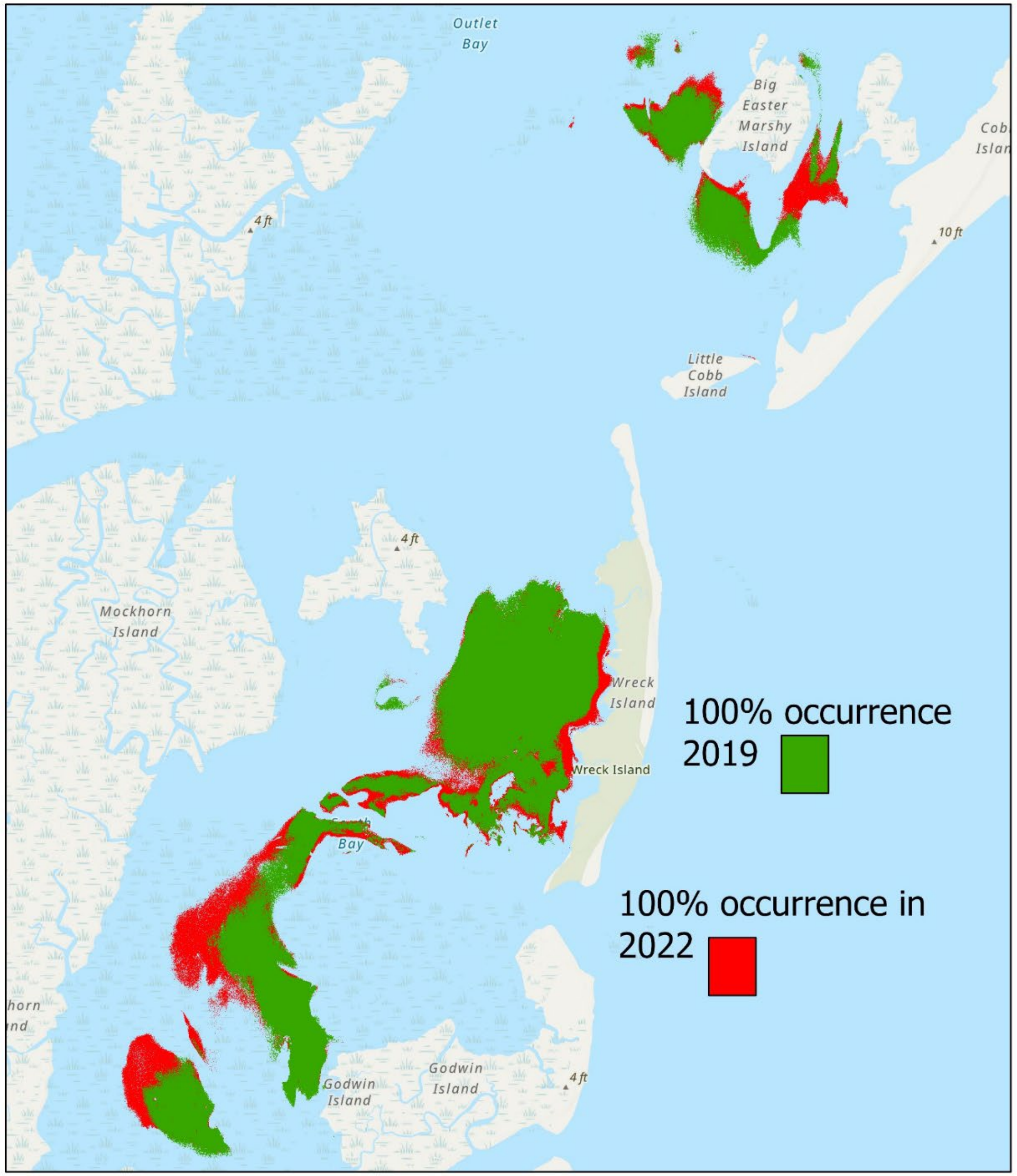


Annual occurrence that an imaged pixel was classified as SAV





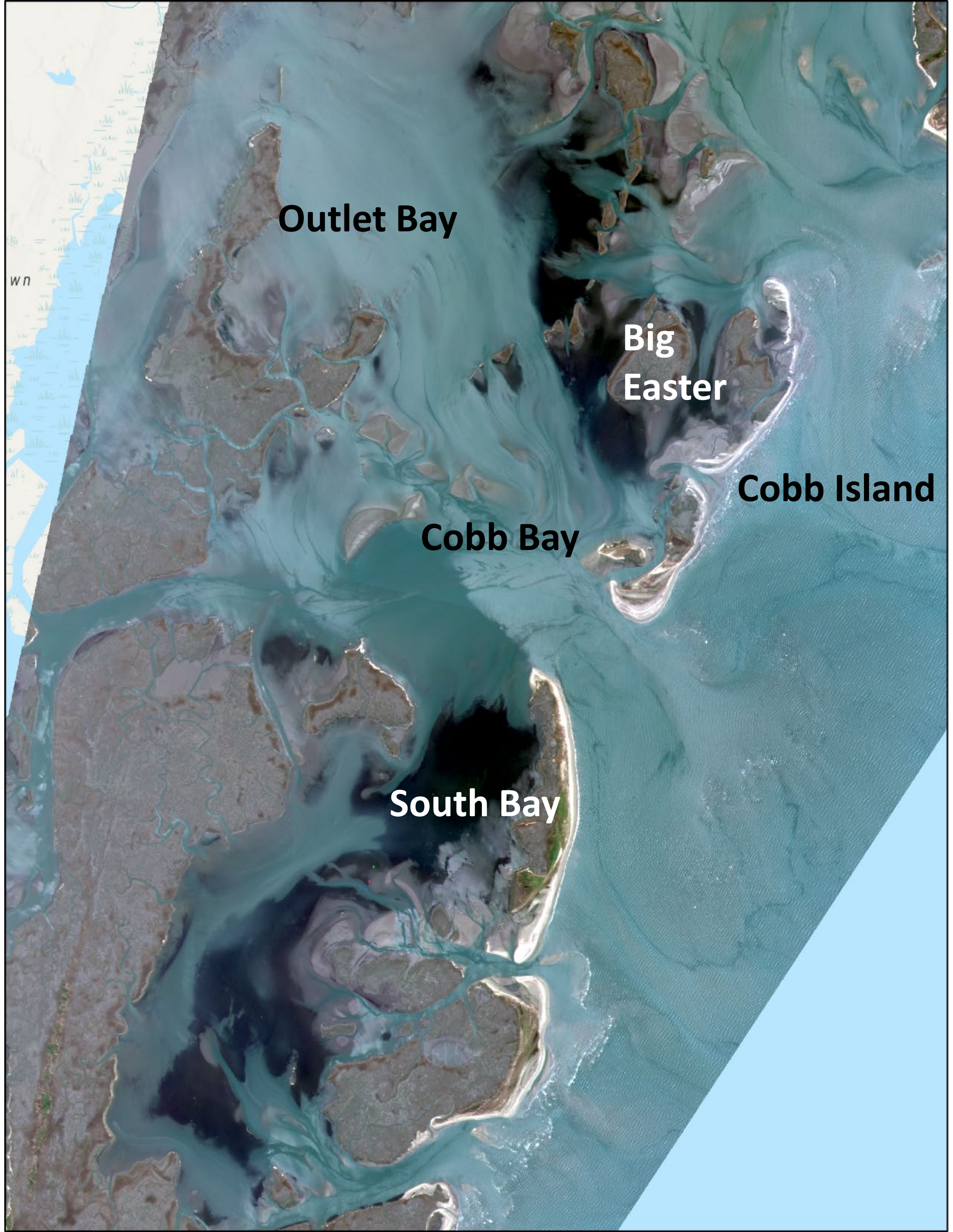
Area of 90-100% occurrence is increasing



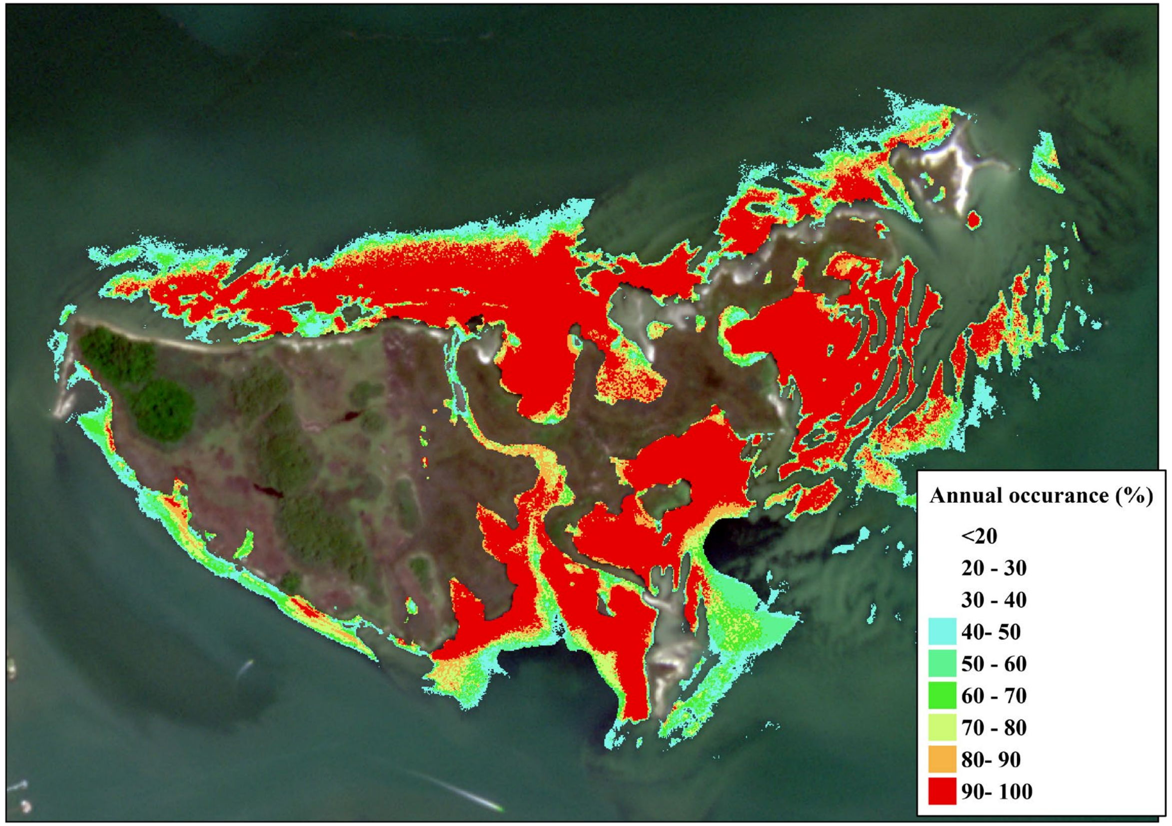
We can detect areas that have increased in density. They show up as changes in 100% occurrence

Fully automated classification

- Successfully trained a classified model for the Eastern Shore using convoluted neutral network (CNN).



Goodwin Island

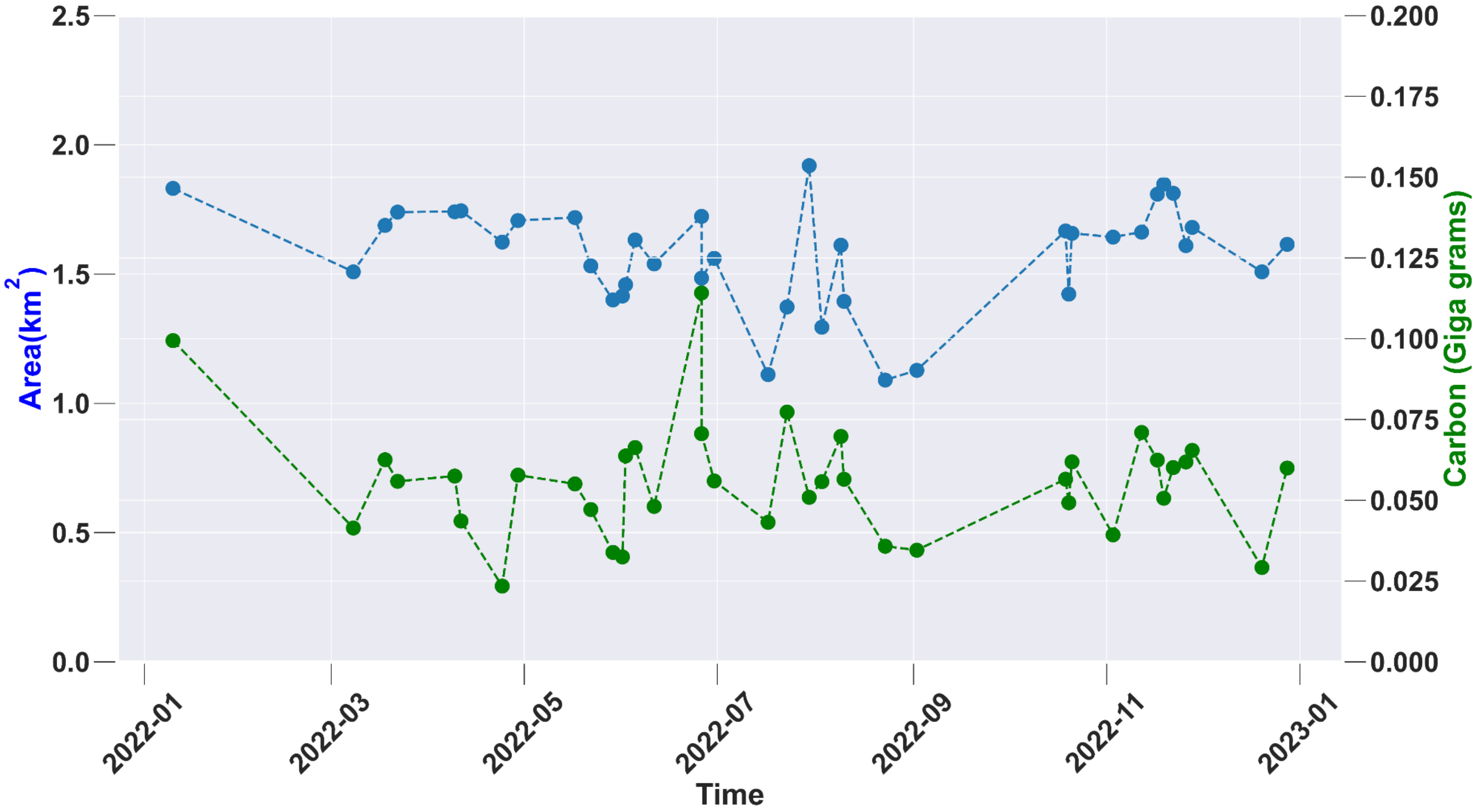


Smaller and less dense SAV meadows dominating the polyhaline environment Goodwin Islands cover an area ~ 1 km^2.

Standing plant biomass = 0.034 Gg of carbon.

Living carbon density = 34 Mg km^2.

Goodwin Island



Smaller and less dense SAV meadows dominating the polyhaline environment Goodwin Islands cover an area ~ 1 km^2.

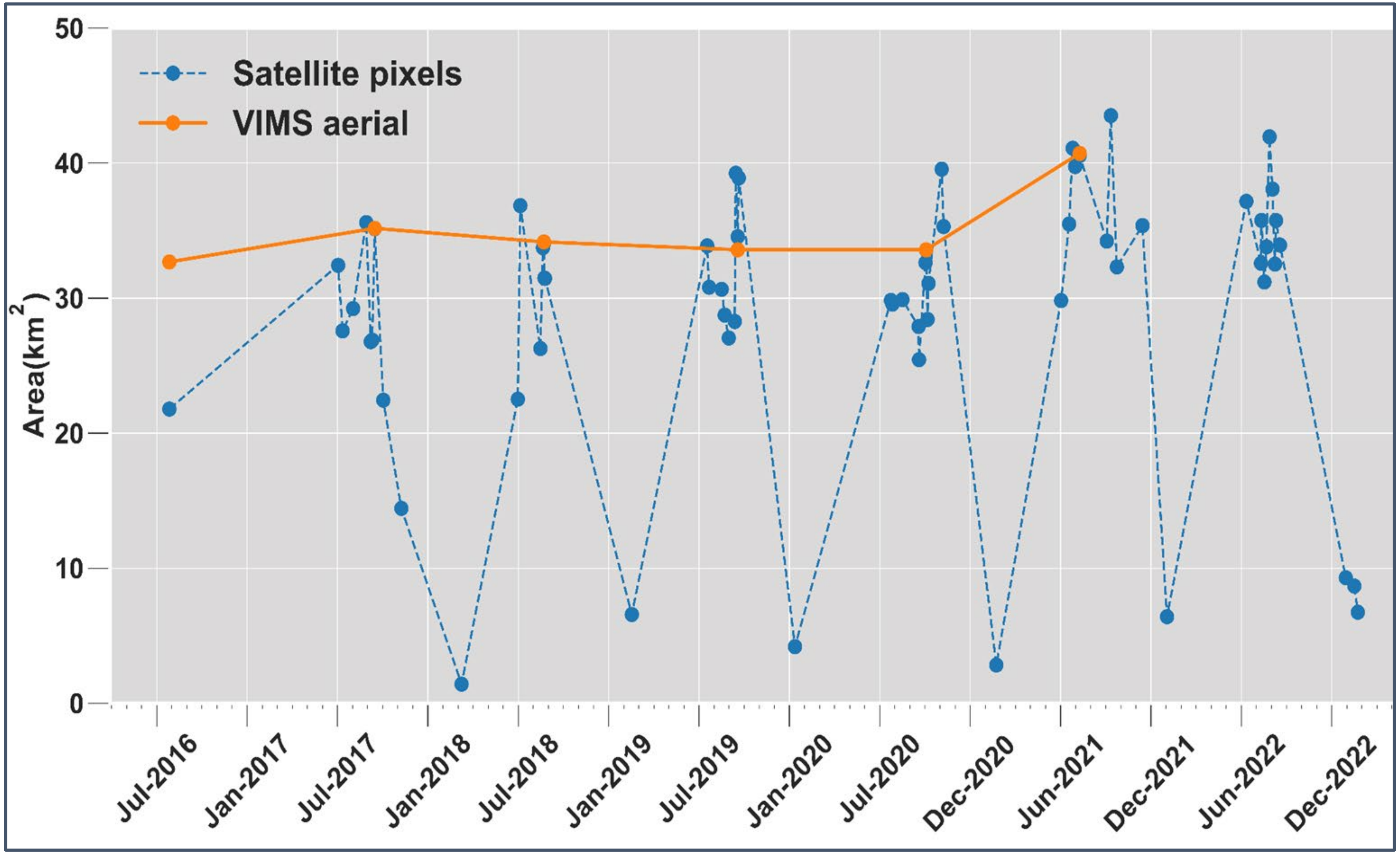
Standing plant biomass = 0.034 Gg of carbon.

Living carbon density = 34 Mg km^2.

Susquehanna Flats – extreme seasonality

SAV meadow in the tidal fresh habitat of Susquehanna Flats covers an area of 29.3 km^2
Summer; Standing plant biomass= 2.11 Gg of carbon
Summer; Living carbon density = 70 Mg km^{-2}.

Susquehanna Flats – extreme seasonality



Santa Rosa Sound, Florida

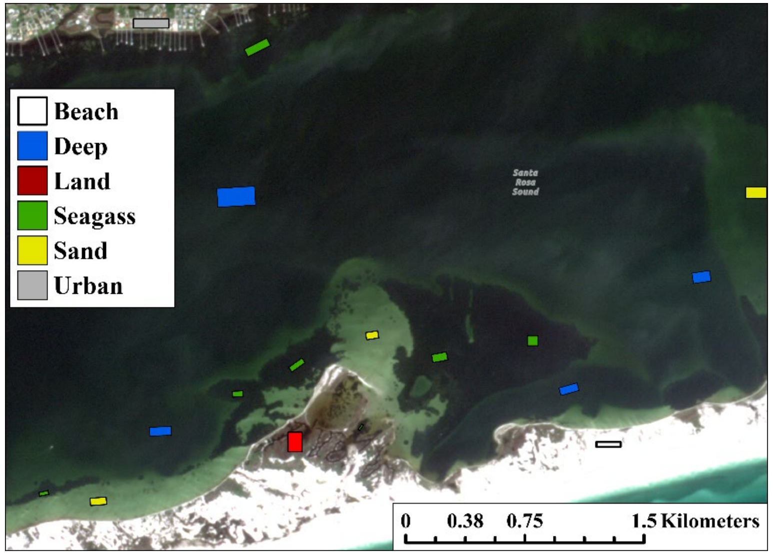


Figure 1. Example of training patches

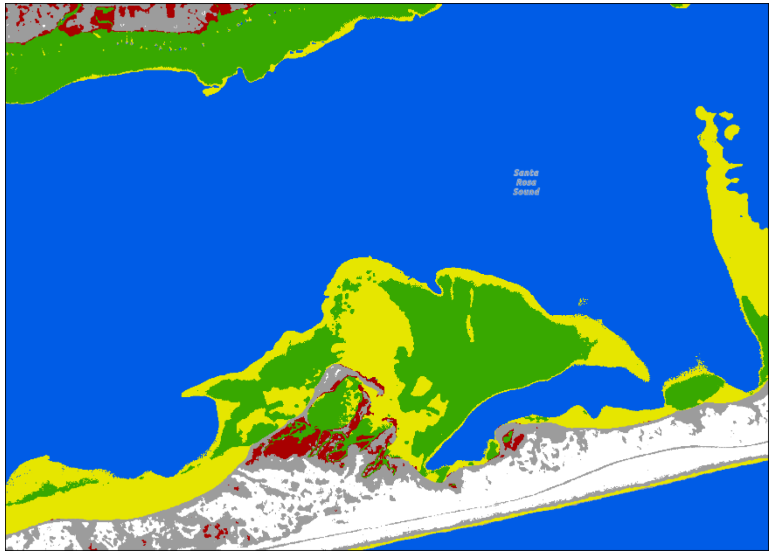


Figure 2. Classified image

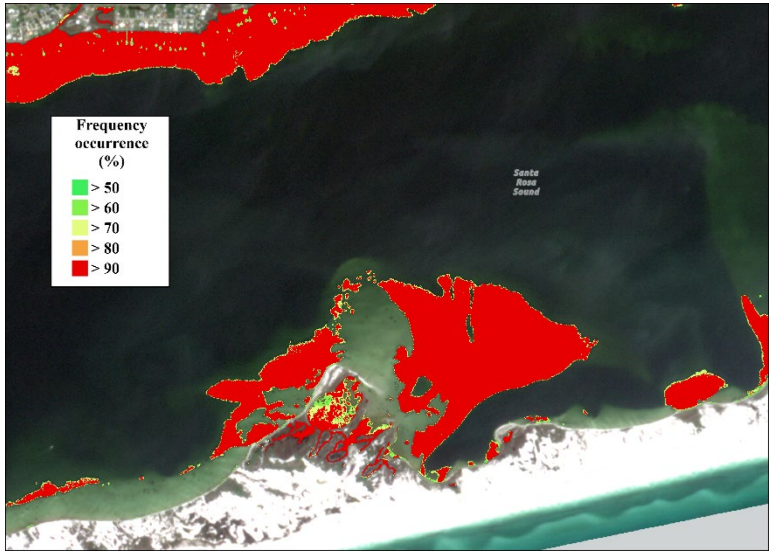
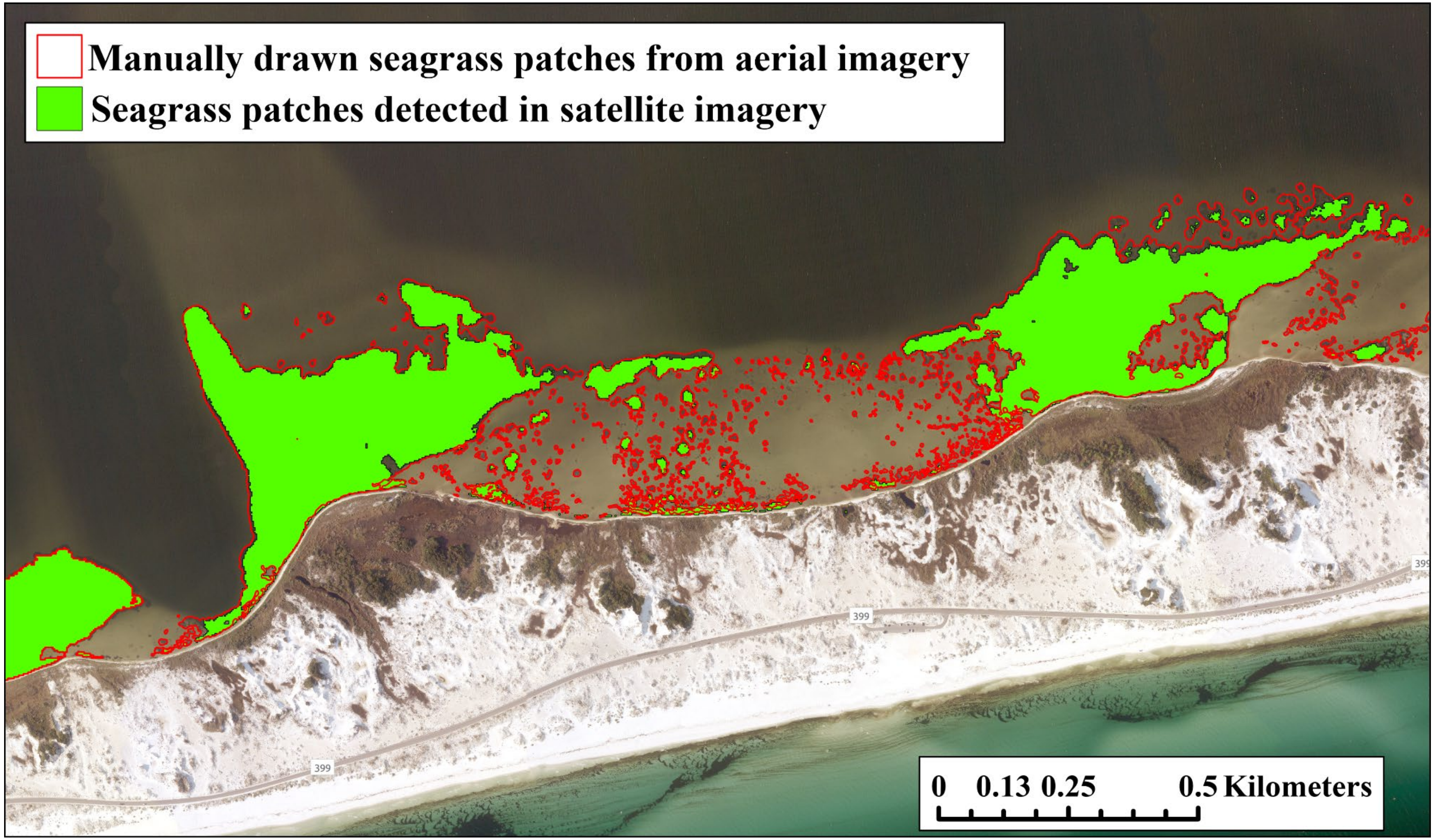


Figure 3. Frequency of seagrass identification

Santa Rosa Sound, Florida

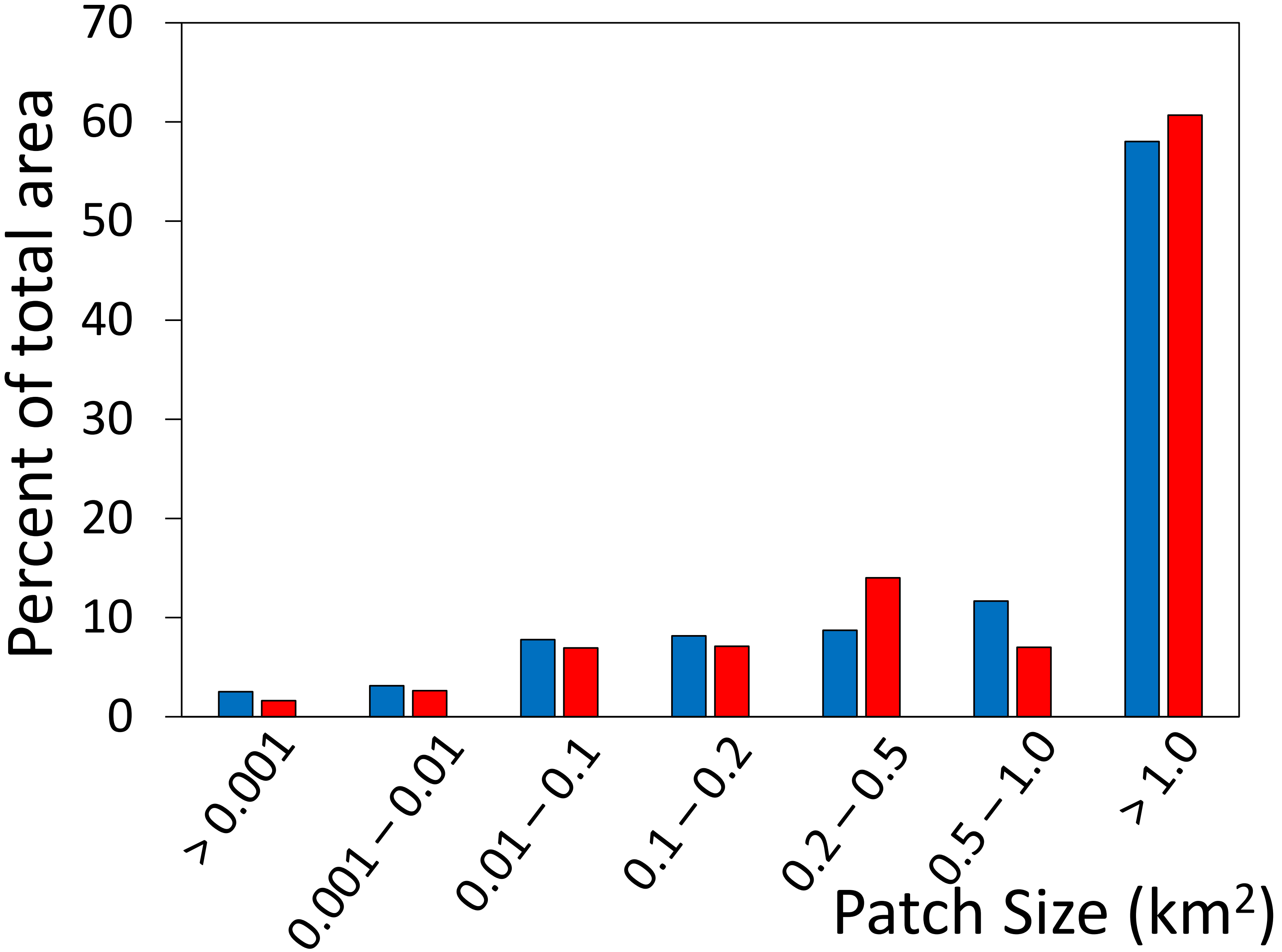
Comparing aerial imagery (Sept 2022), with seagrass mapped from Planet images from September 2022.
Ken Heck and Dottie Byron, Dauphin Island Marine Lab

Santa Rosa Sound, Florida



Planet derived seagrass presence vs manually drawn polygons from aerial imagery

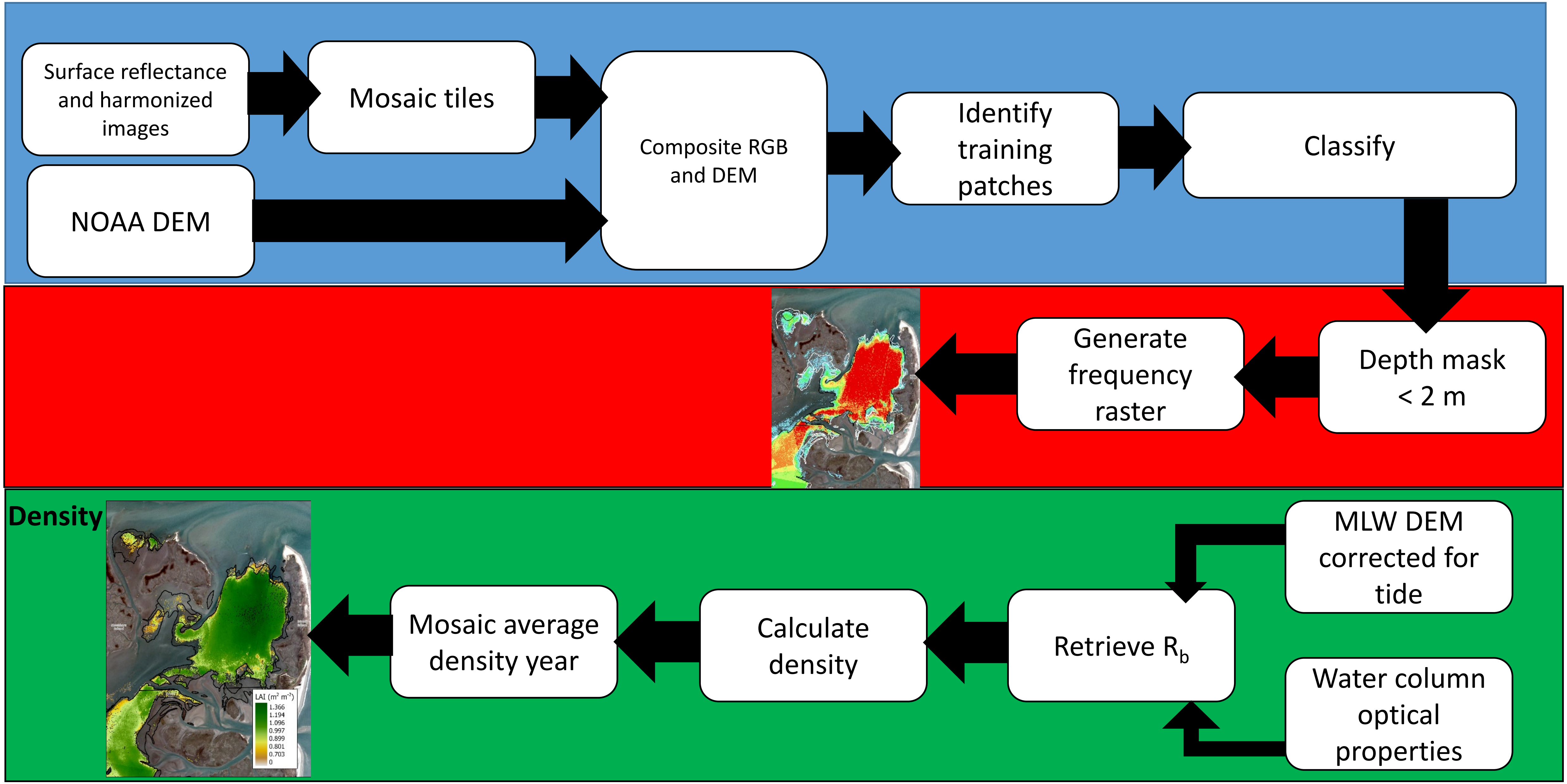
Santa Rosa Sound, Florida



Santa Rosa Sound, Florida

- Total area of seagrass identified via satellite = 10.82 km2
- Total area of seagrass identified via aerial imagery = 11.26 km2
- Patches smaller than 100 m2 are not resolved in the satellite imagery
- Patches of this size represent < 1% of total seagrass area in Santa Rosa Sound
- 97.5 % of total seagrass area is found in seagrass patches > 10,000 m2
- Over 50% of the seagrass was present in continuous meadows of over 1 km2 in area.

Processing workflow



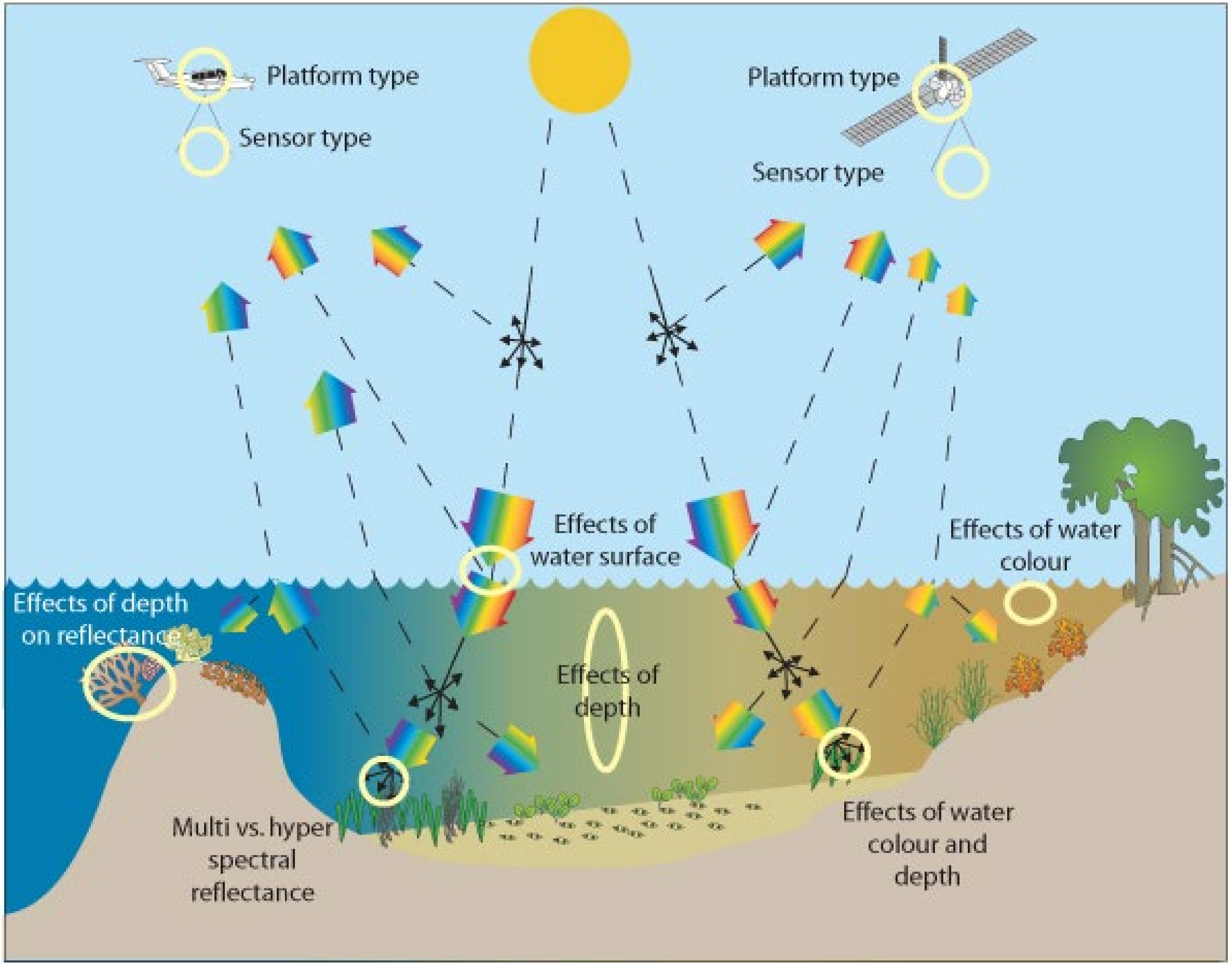
Workshop session 2

- Order data
  - Order Planet image for your study area
  - Order DEM from NOAA data viewer
  - See instructions and files for this in google folder.

- Practice classifying with a DEMO image
  - You will need the DEMO image from the workshop google folder.
    - This image is a 4-band image from South Bay, VA
    - You are going to make a classification schema, and training patches and run a classification.
  - Instructions for classifying in both ArcGIS and QGIS are in the google folder

Workshop session 2

- Quick primer
- Any component of the atmosphere, ocean, land that the light interacts with changes the intensity and spectral shape. Objects differ in how they interact with incident radiation: they absorb, reflect, refract or scatter it . How much radiation an object reflects back at a remote sensor depends on its surface properties, like its size, orientation and chemical composition.



Workshop session 2

Making classification training patches

- Develop a schema in ArcGIS generate training patches.
  - I recommend to always have seagrass as the first item in the schema, So that the class ID is always = 1. This is helpful later in the automated processing.

- Do not make your training patches too big. It is better to have more smaller patches. When the support vector machine model is training on the patches, it takes a subset of pixels from each patch to train the model and then tests it on the remaining pixels those patches. It iteratively changes the model until it gets a good testing result in those pixels. If you make large patches that have a lot of variation in them then your overall classification result may have more misclassifications. ***If you want to capture for example differences in darkness of seagrass meadows, make several small patches that each encompass one type of variation.***

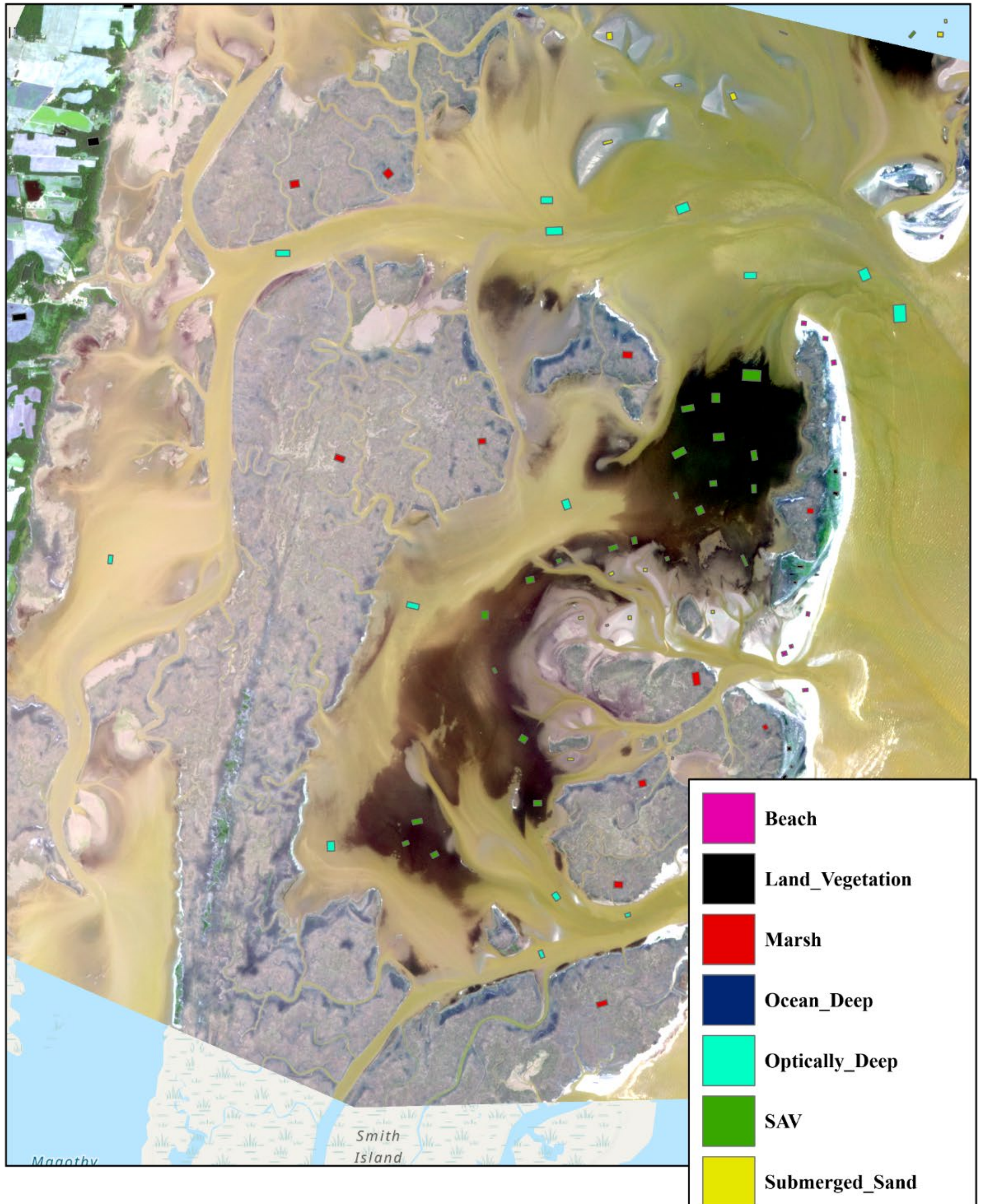
- Aim for ~ 10 patches per target

Workshop session 2

Decide on your classification schema, I am using the schema below. You can make your own, however, always make SAV (seagrass) with a class value of 1. This is important in running the batch codes. You do not need to use all the classes on your schema, but having a master schema that you use instead of a new one for each site is useful for the future.

Class name	Class value
SAV	1
EAV (emergent aquatic veg)	2
Submerged sand	3
Optically deep water	4
Turbid water	5
Ocean deep	6
Beach	7
Marsh	8
Land vegetation (green)	9
Land urban (building, roads etc)	10

Workshop session 2



Workshop session 3

- Downloading your own Planet images, mosaic, composite and classifying.
  - Go to Planet explorer and download the image that you order earlier.
  - Make a folder named after your study site. Inside that folder make another called 0_Zipped. Place your downloaded file within that folder.
  - Now make another folder called 1_Images. When you extract the zipped files place them in 1_Images

Example:

EasternShore_2022

\0_Zipped\your zipped folders

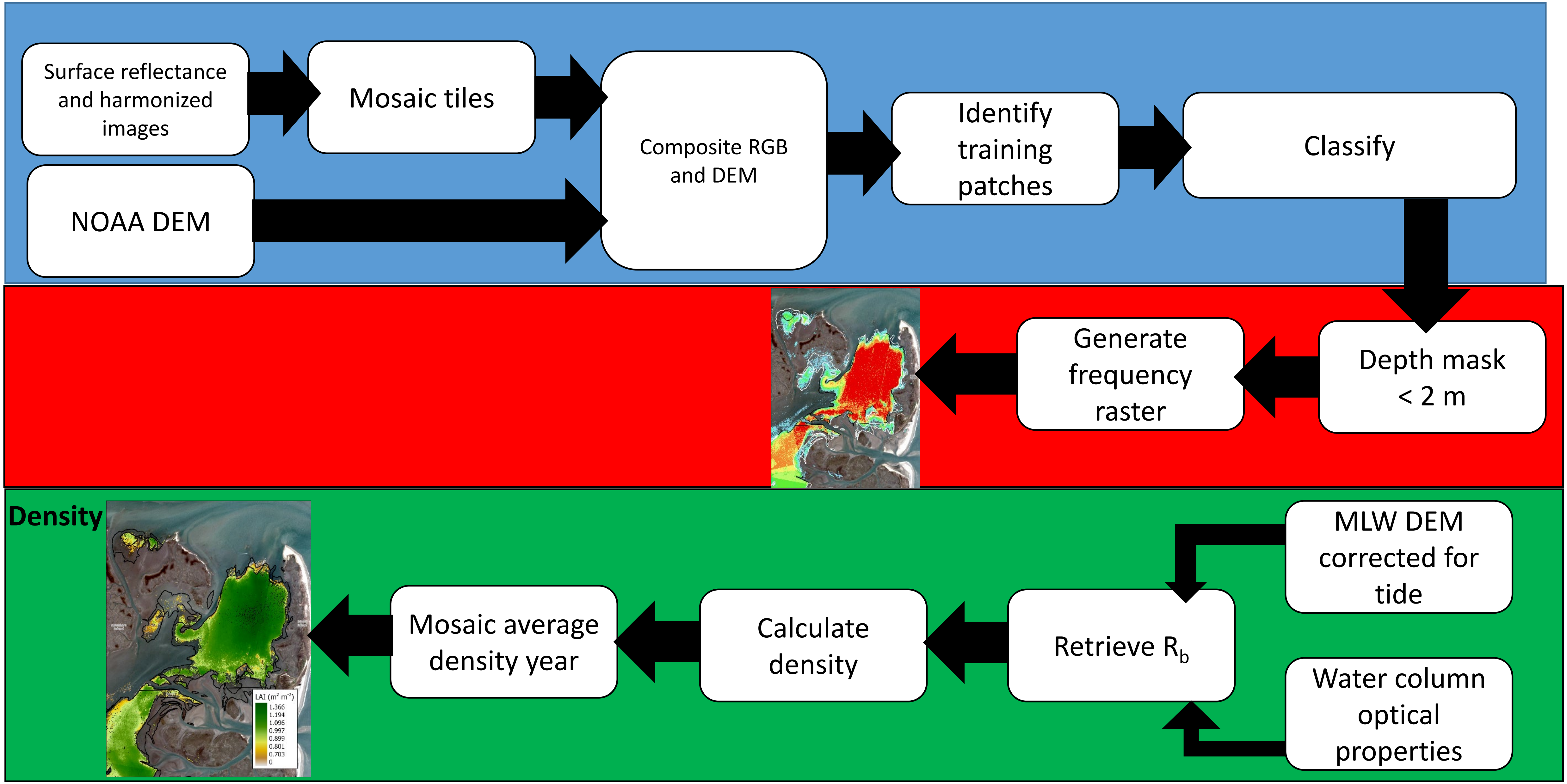
\1_Images\your extracted files from 0_Zipped

Workshop session 3

Directory structure. This is important when using the batch codes.

Folder name	File type	File names (examples)
EasternShore_2023	Top directory, all other folders will reside here.	
0_Zipped	Your downloaded, zipped files	EasternShore_2June2023_psscene_analytic_sr_udm2.zip
1_Images	Unzipped files, in named folders	EasternShore_2June2023\PSScene\20230602_153140_36_2483_3B_AnalyticMS_SR_harmonized_clip.tif
2a_Mosaic	Mosaic tiles, same day, same sensor	20230602_2483_mosaic.tif
2b_Composite_images	Images composited with DEM raster	20230602_2483_composite.tif
3_Classified_composite	Composited images classified	20230602_2483_classified.tif
4_LAI	Retrieved LAI	20230602_2483_LAI.tif
5a_SAV_presence	Presence/absence raster, 1 = SAV, 0 =all others	20230602_2483_SAVpresence.tif
5b_pixels_imaged	Identified valid imaged pixels, 1 = valid pixel	20230602_2483_reclass_imaged.tif

Processing workflow



Workshop session 3

- Processing workflow
- Mosaic
  - Do you need to mosaic tiles together? You may or may not depending in the size of your study area.
  - You can have Planet do this when you order. However, this changes the filename of the image, you can not control how the mosaic is done (blending, first, last etc)

Workshop session 3

- Mosaic tiles if needed. If there are multiple tiles from the same sensor, then you should mosaic them together. ArcGIS pro tool is mosaic to new raster.
  - You can tell if the tiles are from the same sensor by checking the sensor ID.
  - 20200108_152926_1009_3B_AnalyticMS_SR_harmonized_clip.tif
  - 20200108 is the date
  - 152926 is GMT time
  - 1009 is the sensor ID
- I always keep the date and sensor ID in my new file names as I process the images. So, tiles from the same pass once mosaiced become
  - 20200108_1009_mosaic.tif
- I do not recommend mosaicking tiles from different sensors. If you have multiple passes from different sensors on one day, the keep them separate through the processing steps.

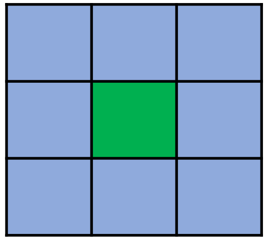
- ****Keeping the same filename structure is important in using the batch processing codes****

Workshop session 3

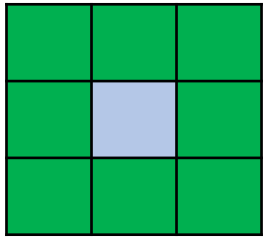
- Processing workflow
- Composite with water depth
  - You will most likely want to do this step, as we have found it improves the classification.
  - This adds another band onto your image (4 to 5 or 8 to 9). Make sure that the DEM band is added as the last band not the first.
  - Input to this is the mosaic image
    - 20200108_1009_mosaic.tif
    - Output is renamed
    - 20200108_1009_composite.tif

Workshop session 3

- Processing workflow
- Post classification refinement
  - I use the DEM after classification to remove all pixels greater than 0 m depth (land) and greater than -2 m depth (deep water). This helps with misclassifications in ponds, lakes on land and any deep water green pixels that for classified as SAV
  - Depth of your cut off will depend on how deep SAV grow at your site.
  - You do not need to do this step if it doesn't help.
  - Shrink tool (in ArcGIS Pro) – can remove single pixels of one class surrounded by other classes. Removes speckling.



  - Expand tool (ArcGIS Pro) – expands pixels of one class to that you can remove single pixels.



Workshop session 3

- Get classifying.
- We are here to help you decide on training patches, targets etc.

Workshop session 4

- Introduction to using Python to batch classify your images, generate annual / seasonal maps.
- Once you have more than 1 or 2 images it becomes easier to batch process your data.
  - Benefits: can reprocess easily, all images treated the same, faster.

Workshop session 4

- My batch codes are in Python using the ArcGIS library ArcPy, you need ArcGIS to use this.
- Converting the code to use QGIS shouldn’t be too hard, does anyone want to get together and do that?
- Will need tkinter if not already installed.
- Codes are in google folder

Workshop session 4

1. unzippmyfiles.py
    1. Unzips files in 0_Zipped and places them in 1_Images

2. PlanetProcessing1_Mosaic_V1.py
    1. Mosaic tiles with same date and sensor number

3. PlanetProcessing2_Clip_and Composite_V1.py
    1. Asks if you want to clip images, composites with DEM

4. PlanetProcessing3_Classify_and_generateFreq_V1.py
    1. Trains and classifies images, for use with one set of ROI for all images
    2. Also masks pixels with DEM after classification
    3. After all images are run it then generates a raster which represents the % of times a pixel was classified as SAV

5. PlanetProcessing3_Classify_and_generateFreq_V1_indivROIs.py (if ROIs are generated for each individual image)
    1. Trains and classifies images, for use if you have an individual set of ROIs for each image.
    2. ROI must be named as follows YYYYMMDD_sensorID.shp (20200108_1009.shp) and must be in folder named \6_ROIs
    3. After all images are run it then generates a raster which represents the % of times a pixel was classified as SAV

6. PlanetProcessing4_LAI_and_generatemean_V1.py
    1. Uses classified images and composite images to calculate LAI
    2. Generates mean LAI after all images run
    3. Outputs .txt file with seagrass area and total above ground carbon

For use with QGIS

1. PlanetProcessing4_LAI_and_generatemean_V1_rasterio.py
    1. Uses classified images and composite images to calculate LAI
    2. Does not calculate a mean right now.

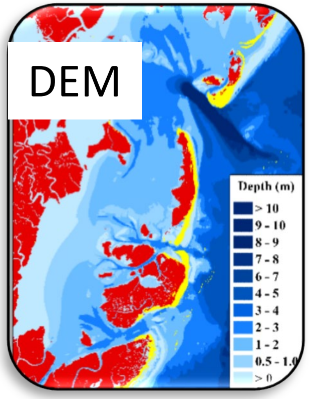
Homework

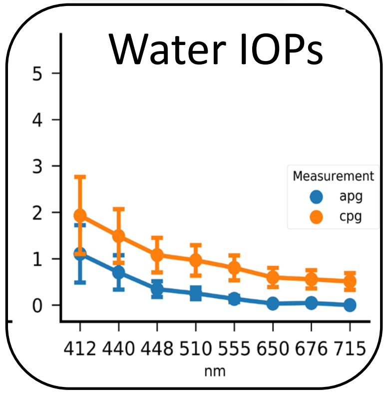
Order more images to try batch codes.

Workshop session 5

- How to estimate leaf area index and carbon from Planet images
  - *Requires an idea of water column optical properties*
  - Water depth
  - Atmospherically corrected reflectance in the green band.

From distribution to density

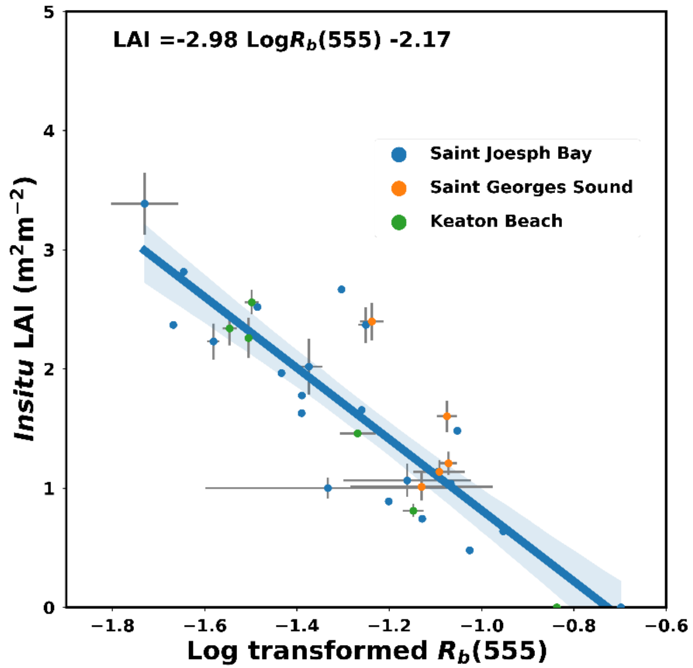




- ***Atmospherically corrected*** R_{rs} from imagery
- $Q_b = E_u(z_b)/L_u(z_b) = \pi$
- K_{Lu} & K_d from *Hydrolight* using measured IOPs
- Water depth, DEM + tide

$$R_b = \frac{R_{rs} Q_b}{t} \frac{\exp\left[-K_{Lu} z_b\right]}{\exp\left(K_d z_b\right)}$$

- z_b – bottom depth from acoustic survey
- t – air/sea transmittance of $L_u(0.54)$



Hill, V. J., Zimmerman, R. C., Bissett, P., Dierssen, H. M., & Kohler, D. (2014). Evaluating Light Availability, Seagrass Biomass, and Productivity Using Hyperspectral Airborne Remote Sensing in Saint Joseph's Bay, Florida. *Estuaries and Coasts, 37*. doi:DOI: 10.1007/s12237-013-9764-3.

Dierssen, H., R. Zimmerman, R. Leathers, T. Downes, and C. Davis. 2003. Remote sensing of seagrass and bathymetry in the Bahamas Banks using high resolution airborne imagery. Limnol. Oceangr. **48: 444-455.**

Workshop session 5

- How to estimate leaf area index and carbon from Planet images
  - *Requires an idea of water column optical properties*
  - Water depth
  - Atmospherically corrected reflectance in the green band.

- Current version of the code
  - Using optical properties of site in Florida
  - Using Rb vs LAI from Thalassia testudinum beds in Florida
  - Out studies indicate that all atmospherically corrected images have residual brightness in the green band. So LAI tends to be underestimated by about 1 m^2 m^{-2}. Based on studies with LandSat and WorldView-2

Workshop session 6

- Best practices for comparing Planet imagery based maps to traditional aerial imagery
- Discussion of working group to manage collecting training data, for developing machine learning models for our study areas.