Seagrass mapping on an intertidal flat at different tide levels using UAV and Sentinel-2

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Abstract: Seagrass beds have great potential to bury carbon, therefore it is necessary to monitor seagrass beds and estimate their carbon burial capacity. However, there are still many knowledge gaps in seagrass carbon stock assessment in intertidal flats of tropical coastal zones, due to complex tidal dynamics interfering with sunlight. Previously, there was a limitation of available imagery that has both sufficient spatial and temporal resolution, which limits our understanding of how the seagrass beds change under different tidal stages. Recently, the launch of Sentinel-2 satellites greatly enhanced the number of available images for analysis. By integrating Sentinel-2 images with UAV images, this paper aims to reveal how the seagrass spectral response changes at different tide levels. To establish the ground truth with a high level of detail about seagrass species and density, a UAV was employed to capture images of the intertidal flat at low tide. With UAV-derived seagrass map as the basis, changes to its spectral responses at different tide levels was examined with time series analysis of Sentinel-2 images. It was found that Sentinel-2 images captured at low tide have high agreement with UAV base map, while images at high tide are influenced by a constantly changing water column. The patterns in changes to seagrass beds reflectance at different tidal stages may enable further understanding of seagrass photosynthesis and carbon sequestration rate on intertidal flats.

1 Introduction

Fig. 1 Change in tidal stages from 11:00-18:00 on 2020-02-05 at Bai Bon, Phu Quoc islands, Kien Giang

Challenge:
Seagrass carbon stock in intertidal flats is uncertain due to changing tides

Objective:
Reveal how seagrass spectral response changes at different tide levels by integrating UAV images and Sentinel-2 images

Significance:
Enable estimation of seagrass photosynthetic activities over time

2 Methodology

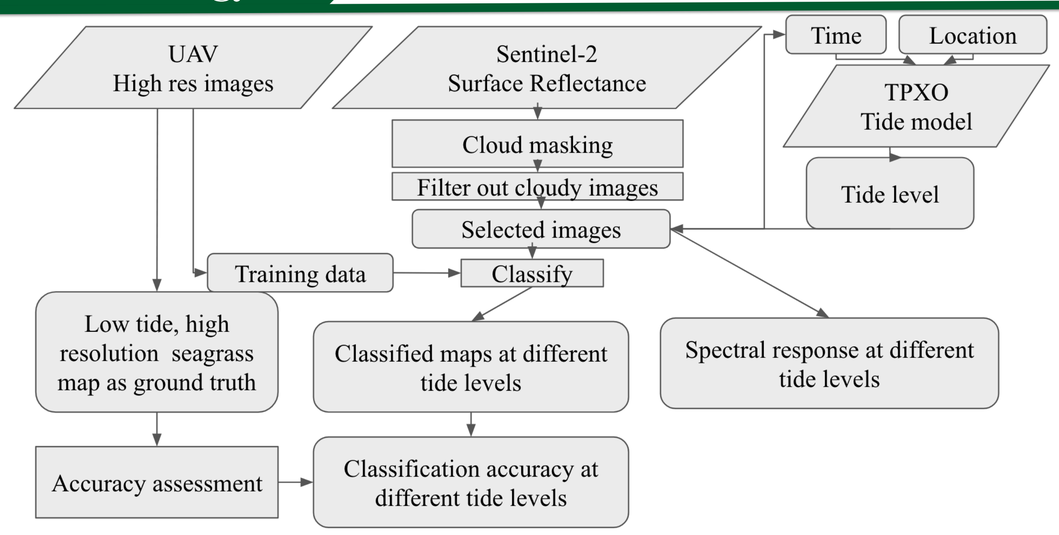
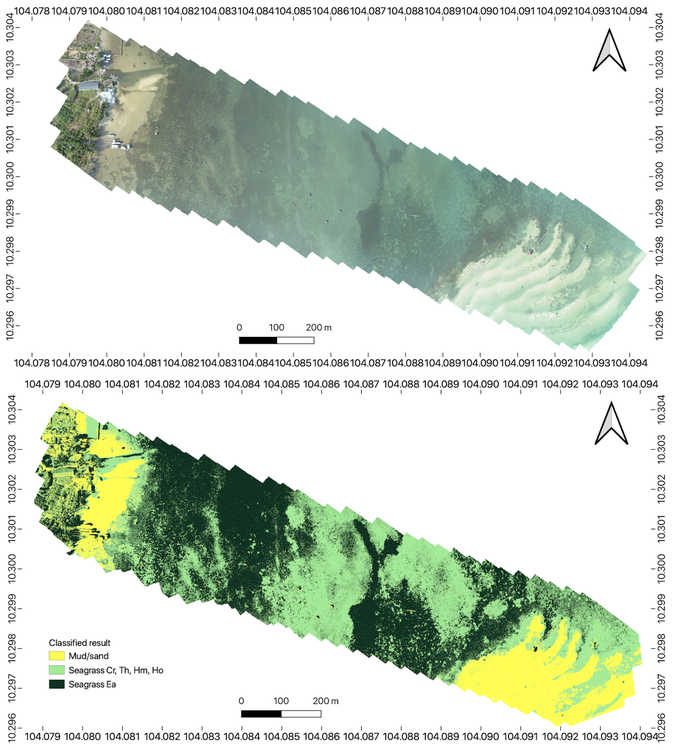
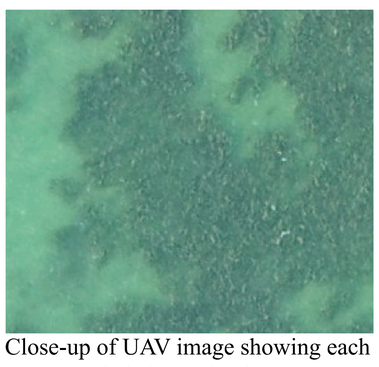


Fig. 2 Overall flowchart of UAV and Sentinel-2 images analysis.

3 Results

3.1 UAV image acquisition classification





Close-up of UAV image showing each seagrass blade is resolved.

Fig. 3 True color composite and classified orthomosaic of the UAV images captured at low tide on 2020-02-05, 15:00.

- 435 images were captured from DJI Phantom 4
- Altitude: 150m
- Spatial resolution: 4 cm
- Area covered: 66.5 ha
- Tide level: -0.3m
- Seagrass beds clearly visible, to each leaf and canopy of *Enhalus acoiroides*

3.2 Sentinel-2 images at different tide levels

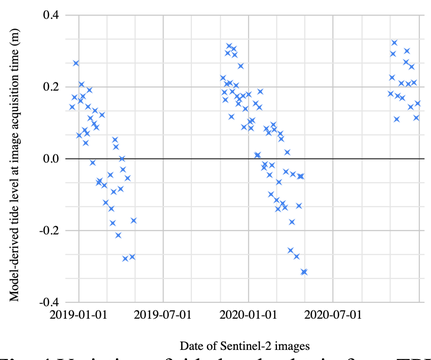


Fig. 4 Variation of tide levels obtain from TPXO global tide model

- 107 Sentinel-2 cloud-free images in dry season between 2018-11-01 and 2020-12-31
- Dry months (November – April) were considered to capture seagrass at maximum growth
- Tide levels at image acquisition time (10:20 am local time) seem to have an annual cycle, high in December, low in March

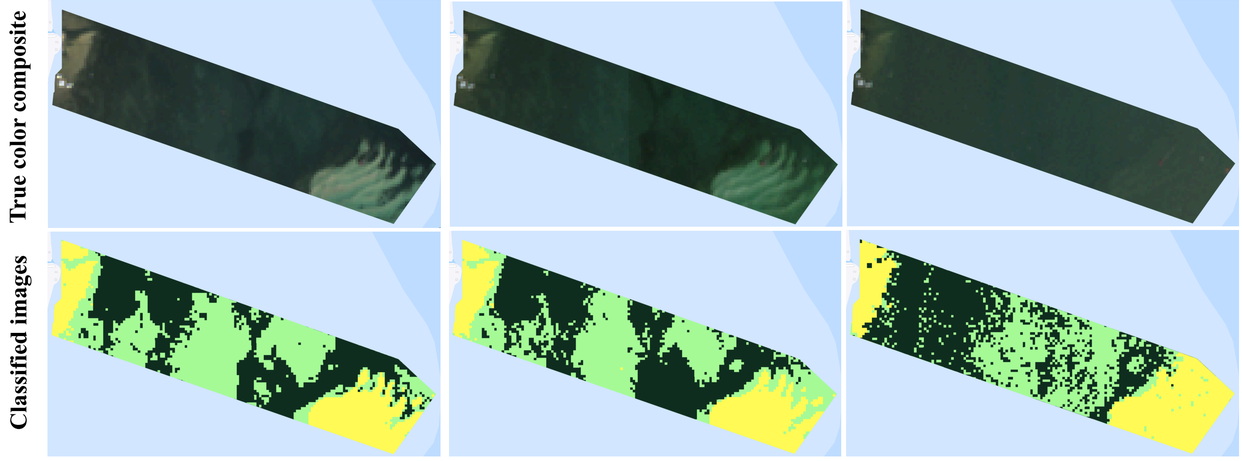


Fig. 5 True color composite and classified images from Sentinel-2 satellites

- Seagrass beds clearly distinguishable from sand at low tide, and medium tide, but less distinct at high tide.

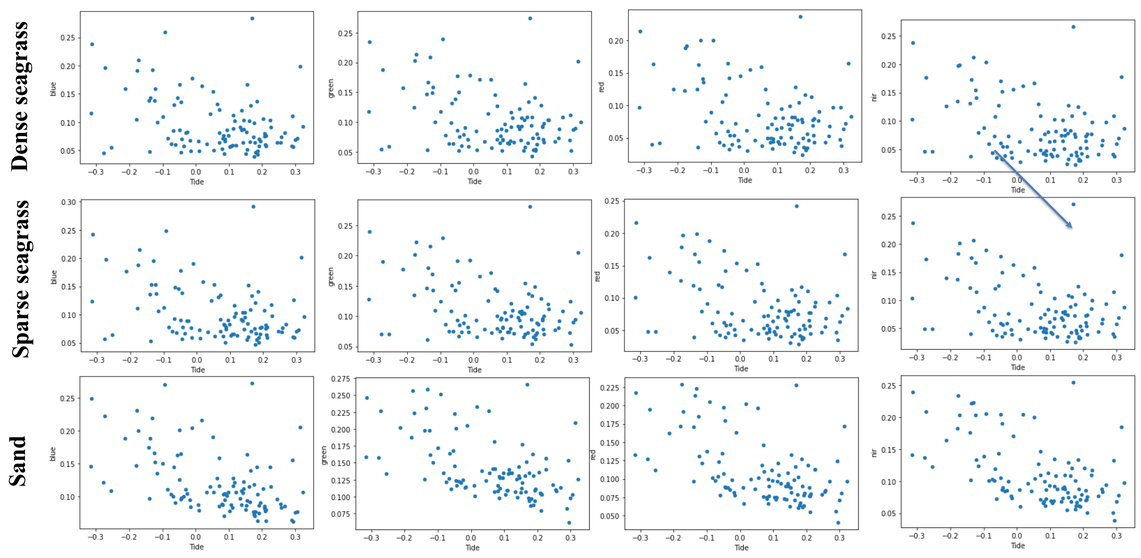


Fig. 6 Reflectance of the blue, green, red, near infrared of Dense seagrass, Sparse seagrass, and sand at different tide levels

- High reflectance seems to correlate with lower tide, especially in sand.

4 Discussion and future work

- The 4 cm spatial resolution of UAV enables further analysis, such as measuring canopy density, percent cover, or species composition.
- Sentinel-2 is highly compatible with UAV images in distribution mapping of seagrass. This allows for integrating Sentinel-2 and UAV images to extrapolate assessment that requires UAV's high spatial resolution, such as percentage cover, species mapping.
- The apparent correlation between reflectance and tides may shed light to further analysis of the water column quality, such as turbidity, suspended sediments. This may in turn reveal further information about the bathymetry of shallow intertidal flats and the properties of photosynthetic activities in seagrass beds.

Future works:
- Further analysis of UAV images
- Examine water column effects on reflectance
- Estimate bathymetry from the variation in tide level
- Investigate on tidal effects on seagrass photosynthetic activities

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