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CENTER OF EXCELLENCE & INNOVATION

Bringing UAS to America's Skies

Activities at Lone Star UAS Test Site and TAMUCC

An update
Scientific Committee for Oceanographic Aircraft Research
December 17, 2020

Presenter:
Michael J. Starek
Associate Professor
Geospatial Systems Engineering

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MANTIS MEASUREMENT ANALYTICS

TEXAS A&M ENGINEERING TEES

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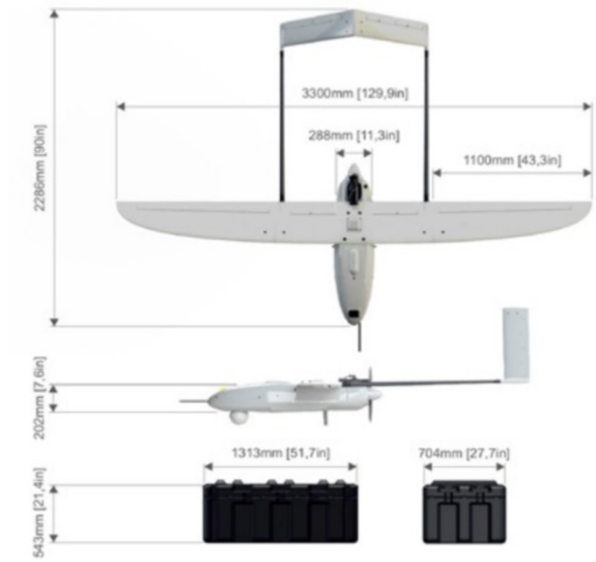
FAA Test Site: ~3600 flights and 250+ customers (to date)

Update information provided by

Tye Payne, Director of Operations, LSUASC

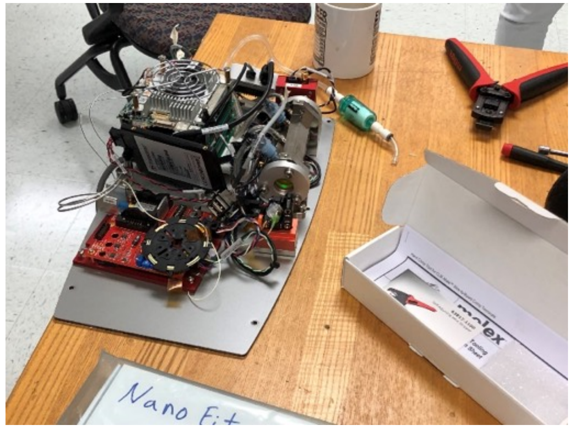
Penguin B/C

- Four pilots scheduled to undergo training on Penguin C in Oregon in January/February 2021
- Functional Check Flights in South Texas completed August 2020 on Penguin B
  - NSF Grant focused on multi-sensor (camera, geo-tracking, and methane) use in a high-endurance platform
  - Functional Check Flights were also used to test small Ground-Based Radar system potentially crucial for manned & unmanned flight deconfliction during disaster operations



Penguin B UAS for methane hydrates developed from NSF MRI

Dr. David Bridges, Dr. Rick Coffin, Dr. Mahdy, Dr. Starek of TAMUCC

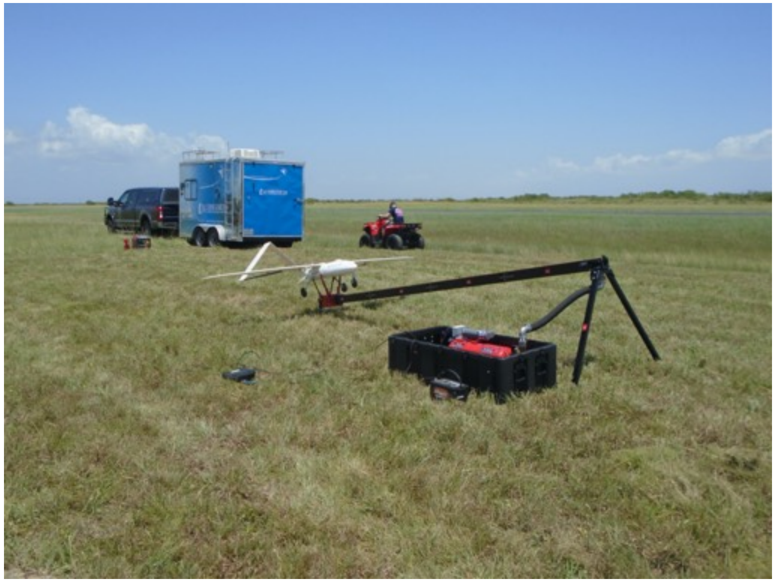


sniffer installed on mounting plate

3D printed mount for Piccolo autopilot and differential GNSS

Sony A6000 + GeoSnap Pro

Penguin B Flight Test in August 2020



Images from Dr. David Bridges

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sUAS Disaster Response

- Exercises conducted in October 2019 with Texas Task Force 1
  - Swiftwater & Search Skills Set Training near Galveston, TX
- Hurricane Response along North Padre and Mustang Island following Hurricane Hanna
  - Operations included coordination with County Judge, Corpus Christi Police Department and Corpus Christi Beach Task Force
- Monitoring of coastal beaches during and following mandatory shutdowns and closures during 2020 COVID response

Moving Past COVID-19 and 2020

- Due to the pandemic, flight operations were dramatically lower than previous years
- Moving into 2021, research focus remains high in the following areas:
  - BVLOS Operations
  - Large UAS Operations
  - Mission/Control Dispatch Centers
  - Traffic Management
  - Disaster Operations

UAS Activities at TAMUCC

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MANTIS MEASUREMENT ANALYTICS

New Project: Developing Survey-Grade Vertical Accuracy UAS Data for Shoreline Projects Using Real Time and Post-Processed Kinematic Solutions

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

Oregon State University

Office of Coast Survey
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Wingtra One
hybrid platform
PPK GNSS and Sony RX1R II 42 MP

Local base station versus longer distance baseline CORS

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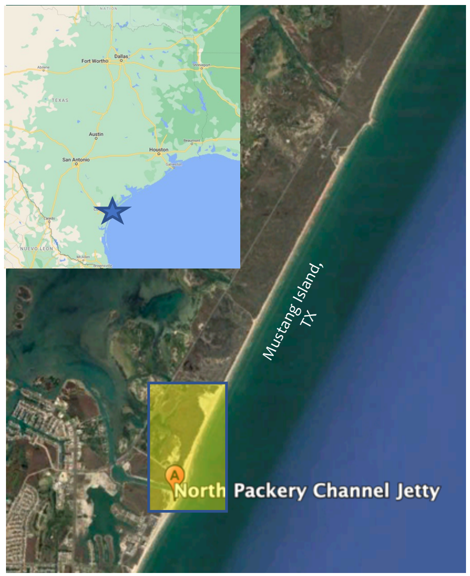
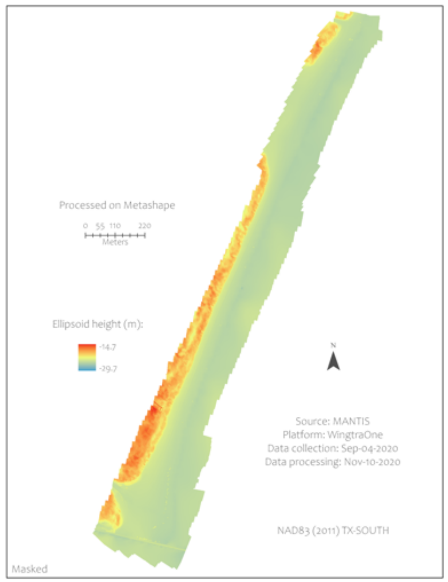
Metashape vs Pix4D vs Drone2Map

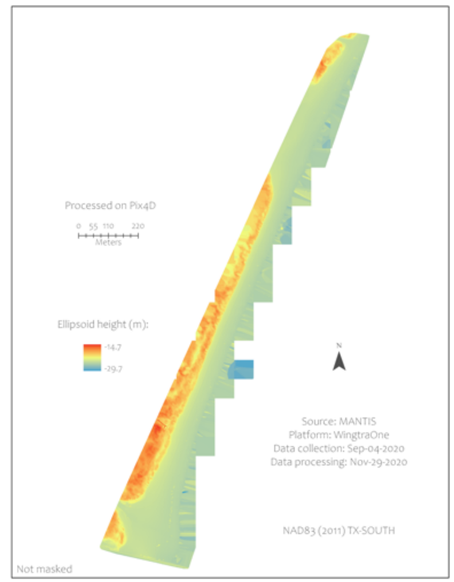
PPK GNSS only solutions, Water not masked during processing



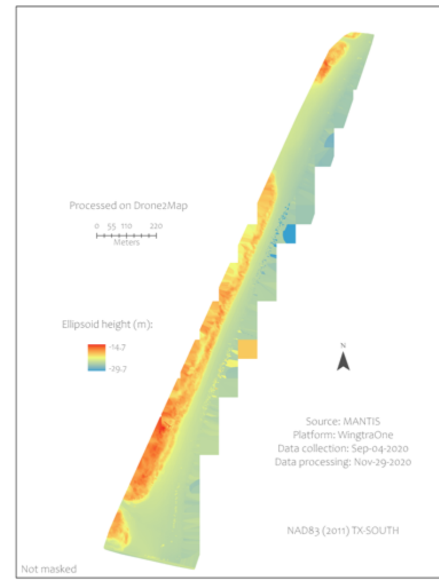
# of photos = 550 | Avg. calibrated = 515
GSD = 1.42 cm | Area = ~ 0.5 square km
Metashape > Strict processing
Drone2Map & Pix4D > Default processing settings



Metashape



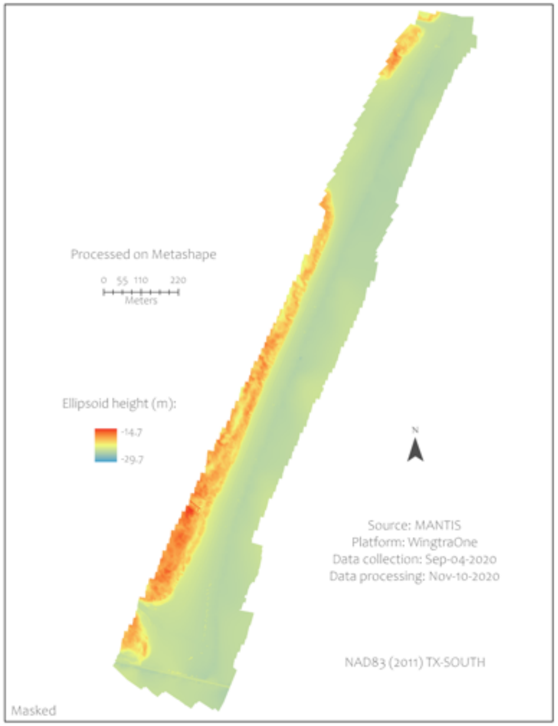
Pix4D



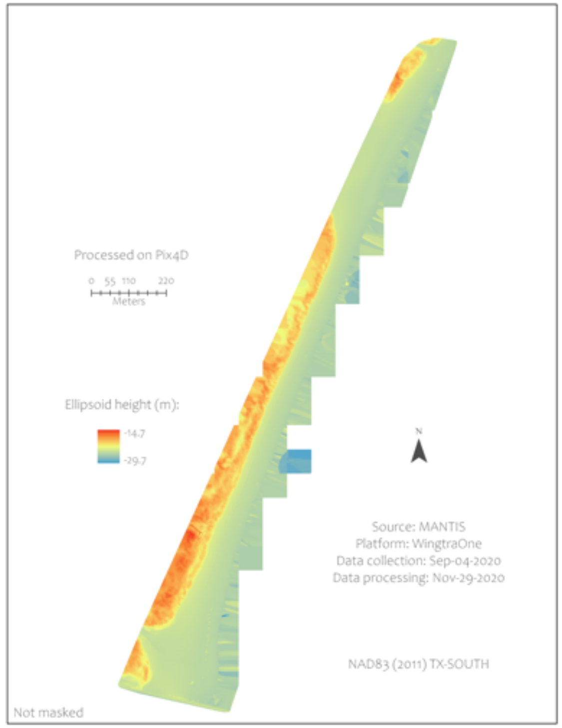
Drone2Map

SfM Generated Digital Surface Models (DSMs)

Metashape vs Pix4D



Metashape



Pix4D

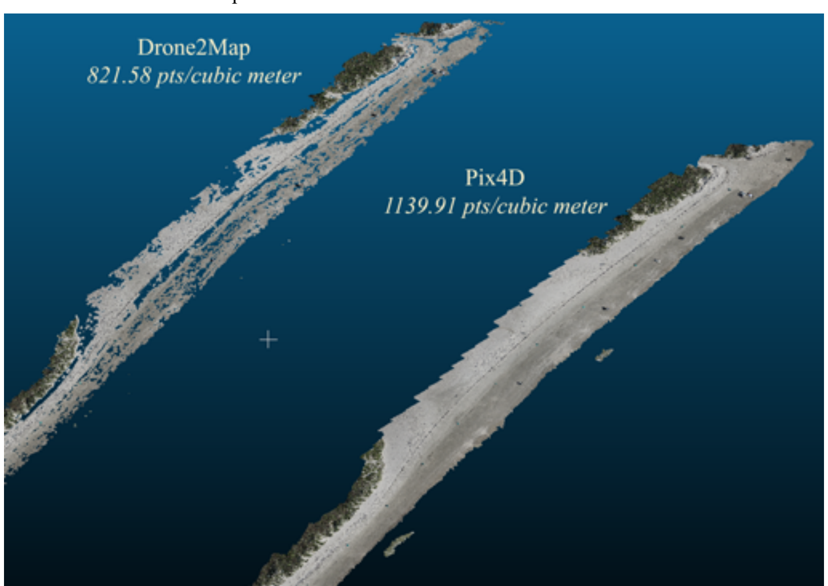
Accuracy: Metashape vs Pix4D

	Metashape RMSE	Pix4D RMSE
X (cm)	2.24533	3.9663
Y (cm)	1.50093	1.7157
Z (cm)	3.49367	4.43711

Effect of Vertical Referencing Choice on Pix4D

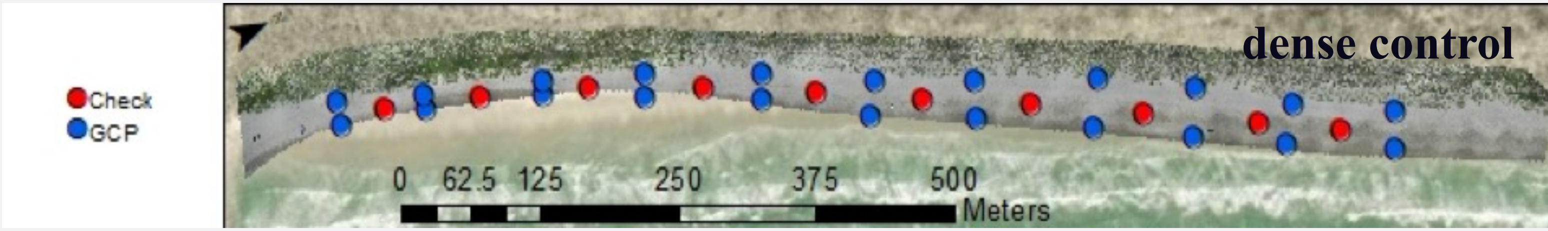
Input choice not as detrimental as output choice

	A **Geotags + Control + Output as Geoid = 0**	**B** **Geotags + Control + Output as arbitrary**	**C** **Geotags as Geoid = 0, Control + Output as arbitrary**	**D** **Geotags as arbitrary, Control + Output as Geoid = 0**
Summary				
Avg. GSD	1.42 cm	1.42 cm	1.42 cm	1.42 cm
Area Covered	N/A	N/A	N/A	N/A
Quality Check				
Median key points p/image	2557	2557	2557	2257
# of calibrated images	515	515	515	515
# of disabled images	35	35	35	35
Relative difference for optimization	0.03%	0.05%	0.05%	0.07
Median matches p/calibrated image	704.098	698.058	698.058	751.553
Absolute Camera Position and Orientation Uncertainties				
Mean X (m)	0.115	0.116	0.116	0.136
Mean Y (m)	0.115	0.117	0.117	0.139
Mean Z (m)	0.162	0.164	0.164	0.461
Mean Omega (°)	0.144	0.148	0.148	0.124
Mean Phi (°)	0.144	0.147	0.147	0.123
Mean Kappa (°)	0.175	0.180	0.180	0.158
Sigma X (m)	0.001	0.001	0.001	0.001
Sigma Y (m)	0.000	0.000	0.000	0.001

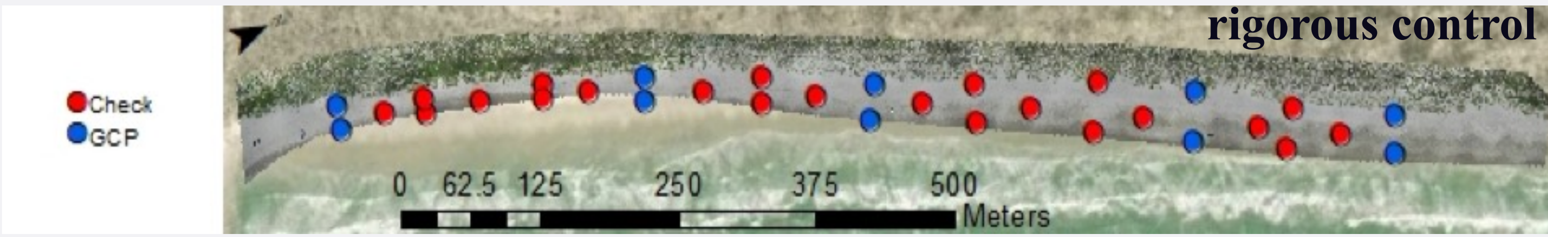


Pix4D vs Drone2Map

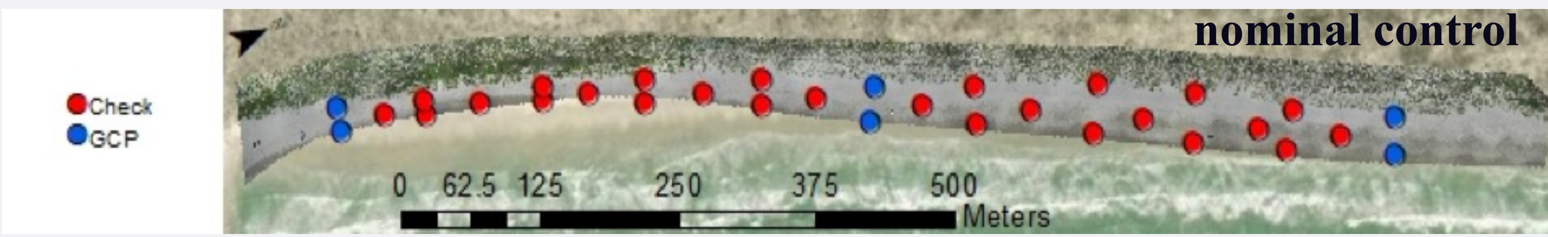
Example UAS surveying ground control network densities



(a)



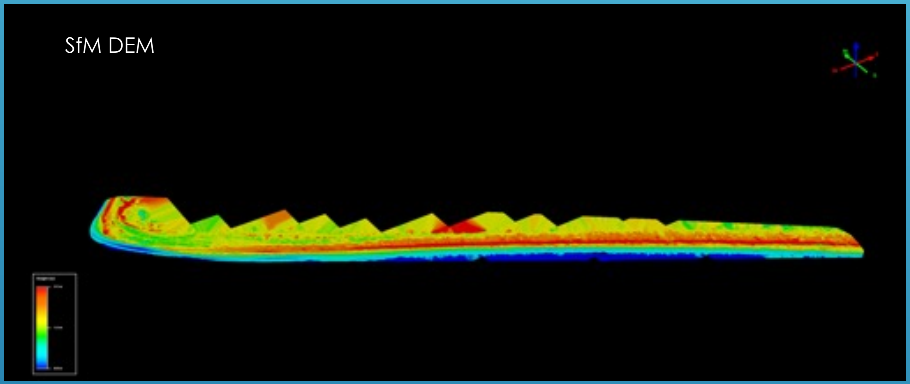
(b)



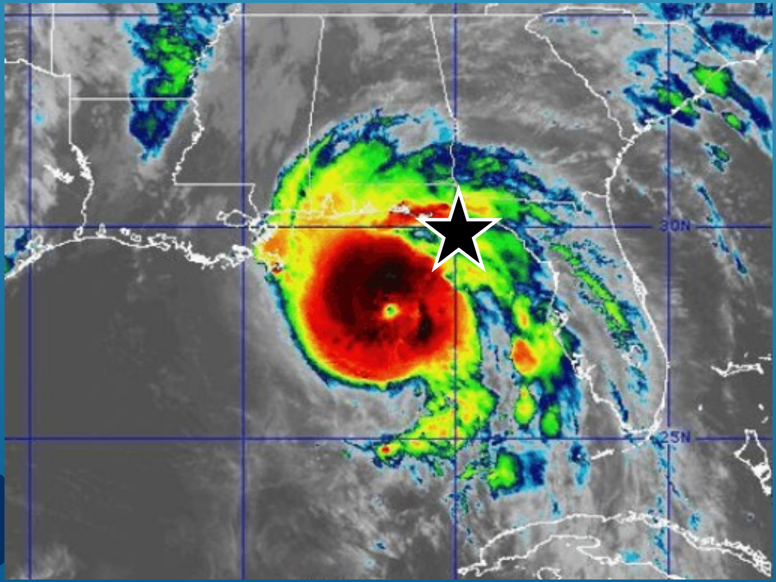
(c)

Apalachicola NERR UAS Survey

Little St. George Island, FL (September 2020)



Mapped the entire Gulf shoreline (9 miles) in 1 day using PPK only solution for georeferencing



Hurricane Michael hit the region back in 2018

AGU FALL MEETING
Online Everywhere | 1–17 December 2020

Fusing UAS-SfM and airborne lidar to evaluate tropical storm impacts and respective recovery of a barrier island subaerial beach and foredune system

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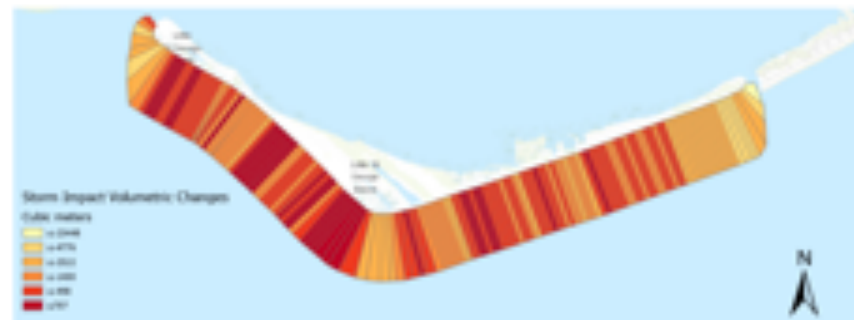
*Conrad Blucher Institute for Surveying and Science (CBI) and The Measurement Analytics Lab (MANTIS) at Texas A&M University - Corpus Christi, Corpus Christi, Texas
^The Apalachicola National Estuarine Research Reserve, Apalachicola, Florida

Background and Objectives

respective recovery from such events to develop effective conservation strategies. Airborne lidar has typically been utilized to generate elevation models for post-storm recovery quantification efforts but is expensive to deploy, which can result in poorer spatial and/or temporal resolution of the data. Alternatively, recent advancements in unmanned aircraft system (UAS) structure-from-motion (SfM) technology has been adopted to quantify storm recovery and has yielded data products with comparable accuracies to lidar. However, to the best of the author's knowledge, no studies seek to fuse publically available lidar and UAS-SfM derived elevation models to quantify the short-term recovery of a barrier island subaerial beach and foredune system.

This research expands on previous work that quantified the impact of Hurricane Michael on Little St. George Island, Florida for the Apalachicola National Esuarine Research Reserve (ANERR). The objectives of this study are I) to quantify the short – term recovery of Little St. George Island, Florida's subaerial beach and foredune system from the impacts of Hurricane Michael, and II) generate a novel workflow to quantify this recovery by fusing UAS-SfM and lidar derived elevation models to determine the potential of integrating SfM for future recovery and impact analyses.

Results



Methods

Figure 4. Aerial view of the derived point cloud of the beach from the UAS-SfM survey at the beach and foredune interface.

Conclusions and References

Little St. George, according to the quantitative analyses thus far, appears to still be experiencing net erosion following the impact of Hurricane Michael. The elevation difference grid depicts the spatial trends of the volumetric analyses,indicating much of the erosion is occurring in the backdunes whereas most of the accretion is occurring on the exposed beach.

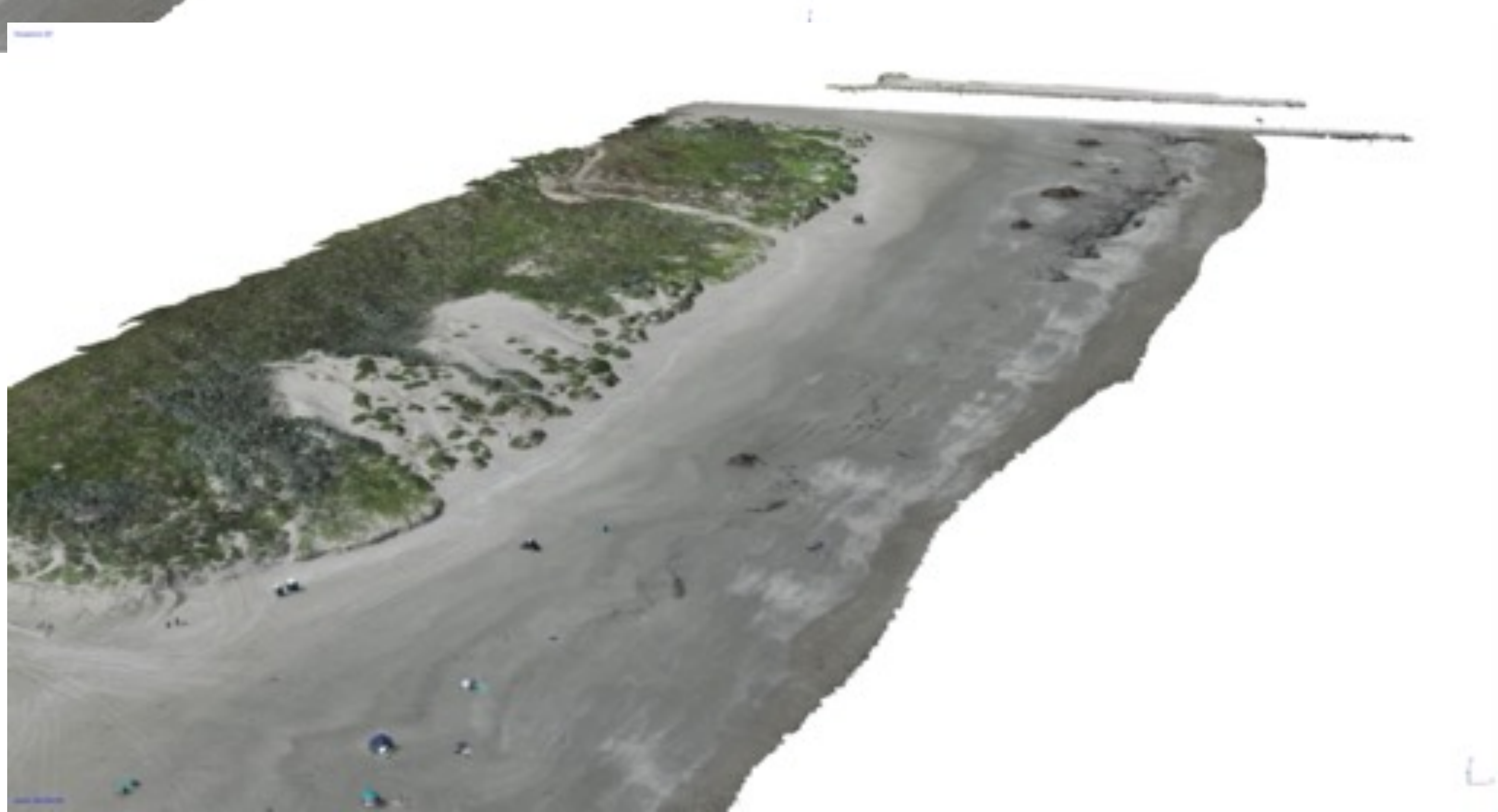
The vertical accuracy results of the UAS-SfM derived elevation model exceed those provided by the lidar derived post-storm elevation model. The dense point cloud generated by the SfM processing resulted in the ability to derived an accurate, high-resolution elevation grid capable of being utilized in the recovery quantitative analyses in conjunction with the lidar model. Therefore, the results of this study indicate UAS-SfM can be used as an affordable alternative to lidar at local scales to monitor hurricane impacts and recovery within coastal zones.

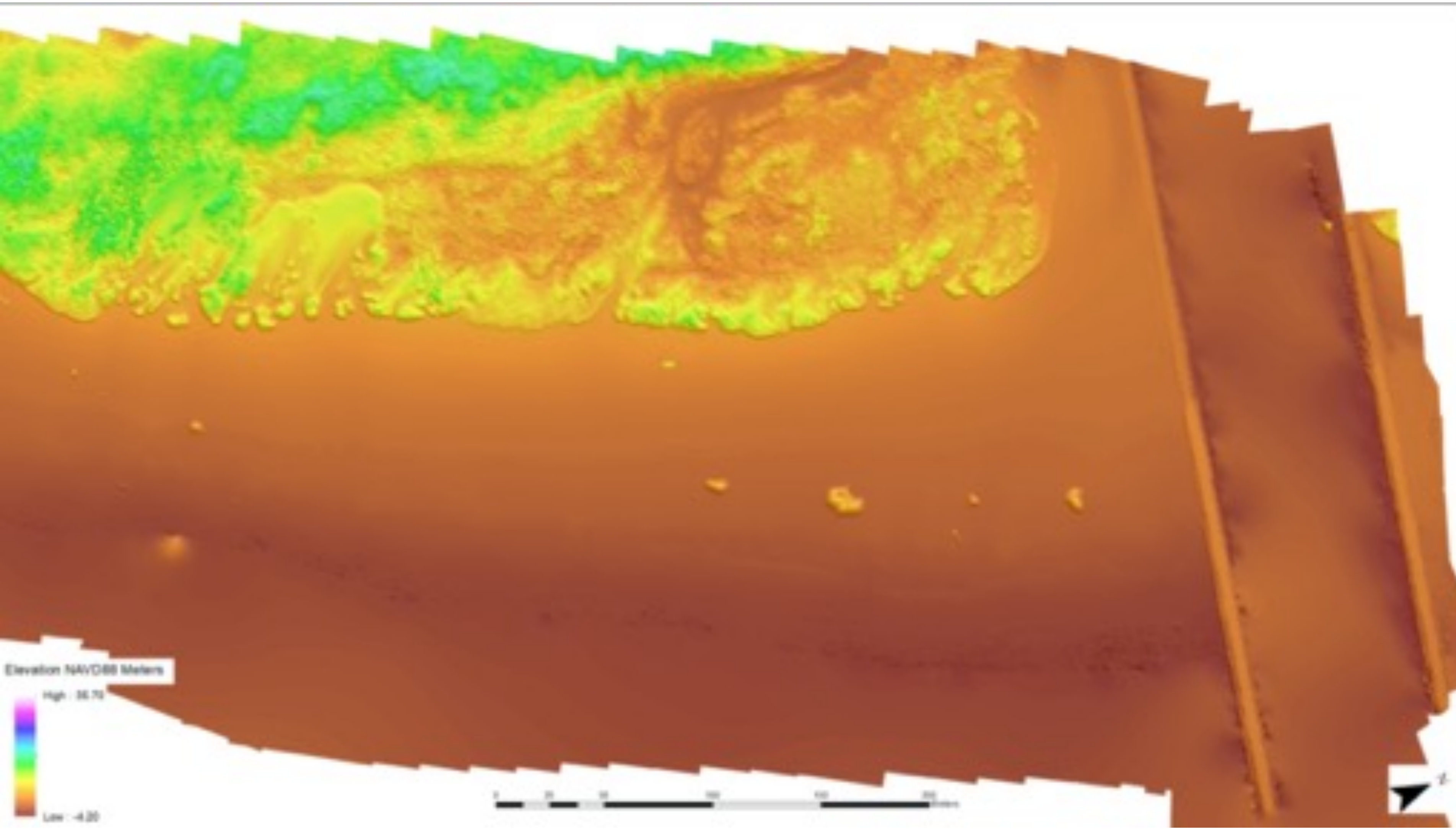
Limitations of this technology must be considered. The SfM generated point cloud produced heavy noise where there were water features (e.g. the shoreline) and regions of high homoegeneity in the scene. Furthermore, the water was too turbid for SfM to map submerged terrain. Finally, SfM cannot capture many ground points in densely vegetated regions, causing a lack of data points and increasing potential error of the elevation interpolation.

Post-Hurricane Hanna UAS Flights for Nueces County, TX

Location: **North Padre Island, TX**
Date**: 07/29/20**


Massive
foredune cuts



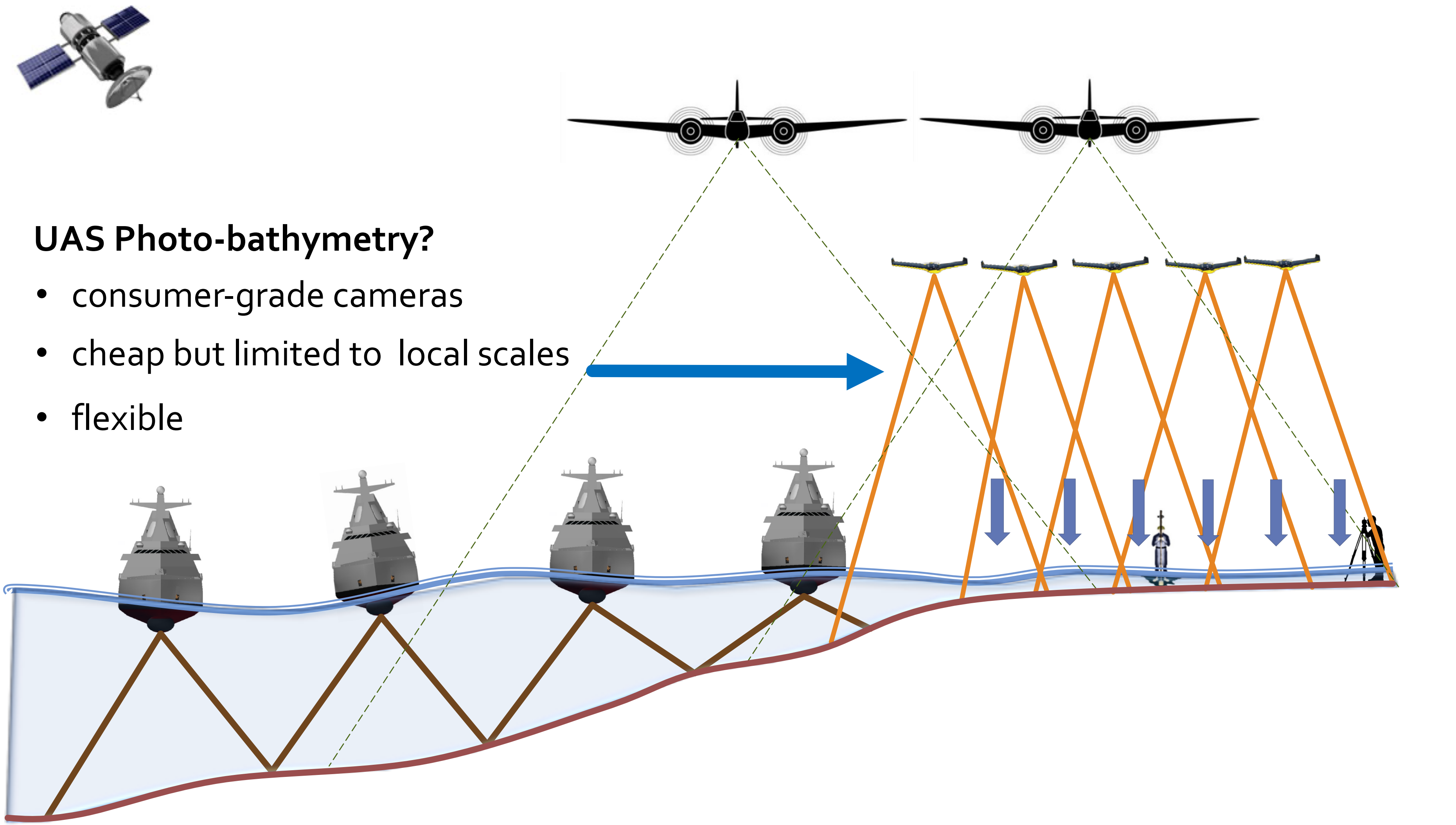


Elevation NAVD88 Meters
High : 36.70
Low : -4.20

Bathymetric Surveying

UAS Photo-bathymetry?

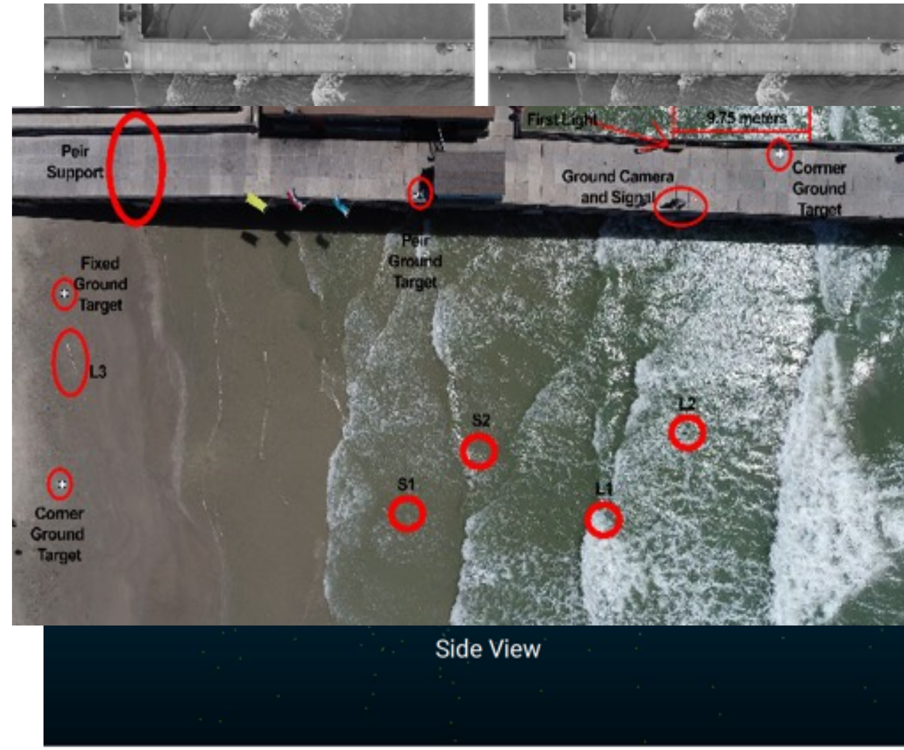
- consumer-grade cameras
- cheap but limited to local scales
- flexible



(image source: NTS)

Example

Particle Image Velocimetry (PIV) for Surf Zone (temporal approach)



Experiments conducted at Bob Hall Pier, TX (latest results from Summer 2019)

1. Python PIV sequential image pair
2. Image stabilization
3. Estimate velocity vector field
4. Estimate depth

Research Experiences
For Undergraduates

Based on linear water wave theory, the dispersion relationship relating the water depth (h), the wave angular frequency (ω) and the wave number (k) can be given as [8],

$$\omega^2 = gk \times tanh(kh) \qquad (1)$$

where $k = 2\pi / \lambda$, $\omega = 2\pi / T$

in shallow water

$$tanh(kh) \approx kh$$

simplifying Equation (1)

$$c = \frac{\omega}{k} \approx \sqrt{gh}$$

PIV estimated wave celerity "c" is used in equation to estimate depth ***h***

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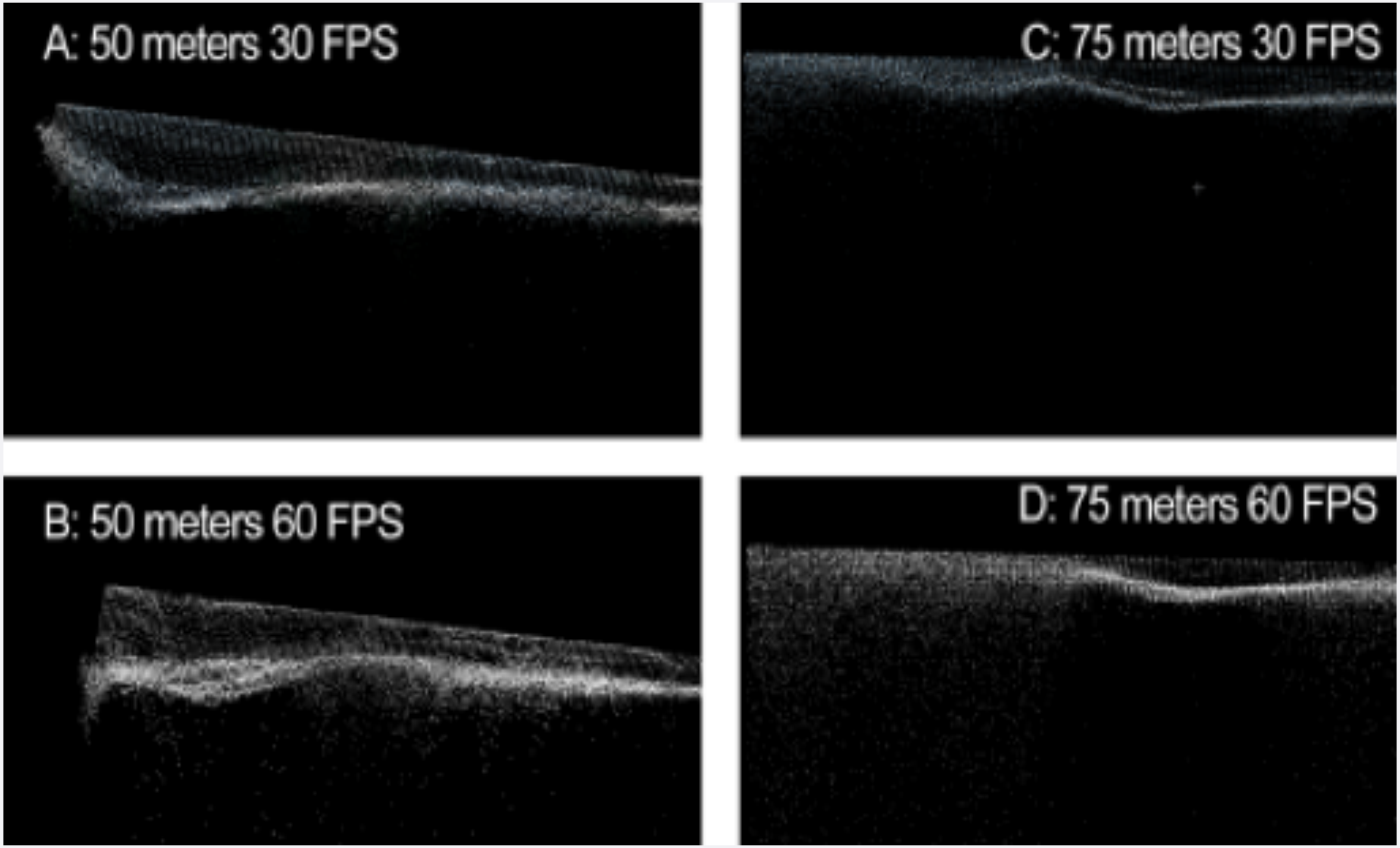
*note: there are other more advanced wave celerity & depth relationships

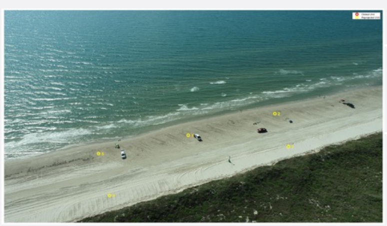


- Automated wave crest velocities almost 3x slower compared to manual wave crest measurements throwing off the bathymetry calculations
- Yielded accurate sandbar shape and bathymetry profile shape
- With compensation, within 5% of ground truth depths **at 50 m & 30 fps**

Jesse McDonald, Jason Pollard, Michael J. Starek, Dulal Kar. 2020 (in press). Surfzone Bathymetry Estimation Using Wave Characteristics Observed by Unmanned Aerial Systems. In *IGARSS 2020-2020 IEEE International Geoscience and Remote Sensing Symp*osium. IEEE.

Example
cBathy: A robust algorithm for estimating nearshore bathymetry (spectral)

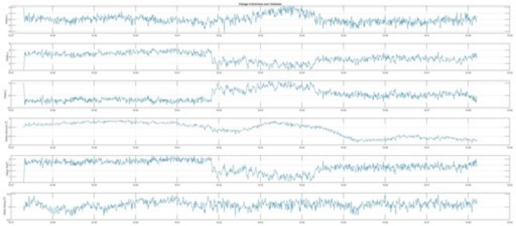
Phantom 4 Pro RTK



2Hz frame rate

Holman, R., Plant, N. and Holland, T., 2013. cBathy: A robust algorithm for estimating nearshore bathymetry. *Journal of geophysical research: Oceans*, *118*(5), pp.2595-2609.

Calculation of Camera POSE in Time



Generation of Grid for Depth Calculation

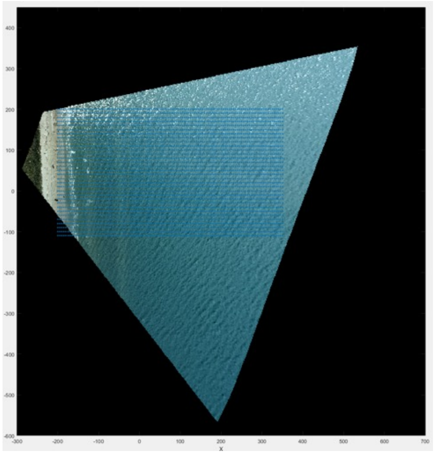
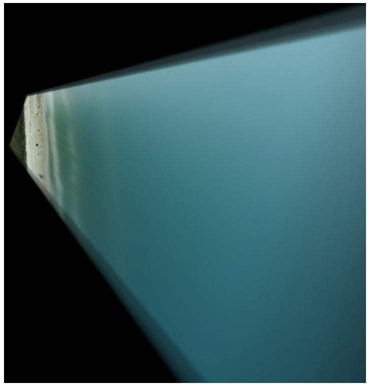
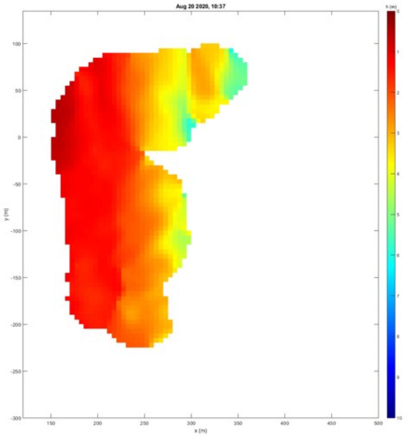


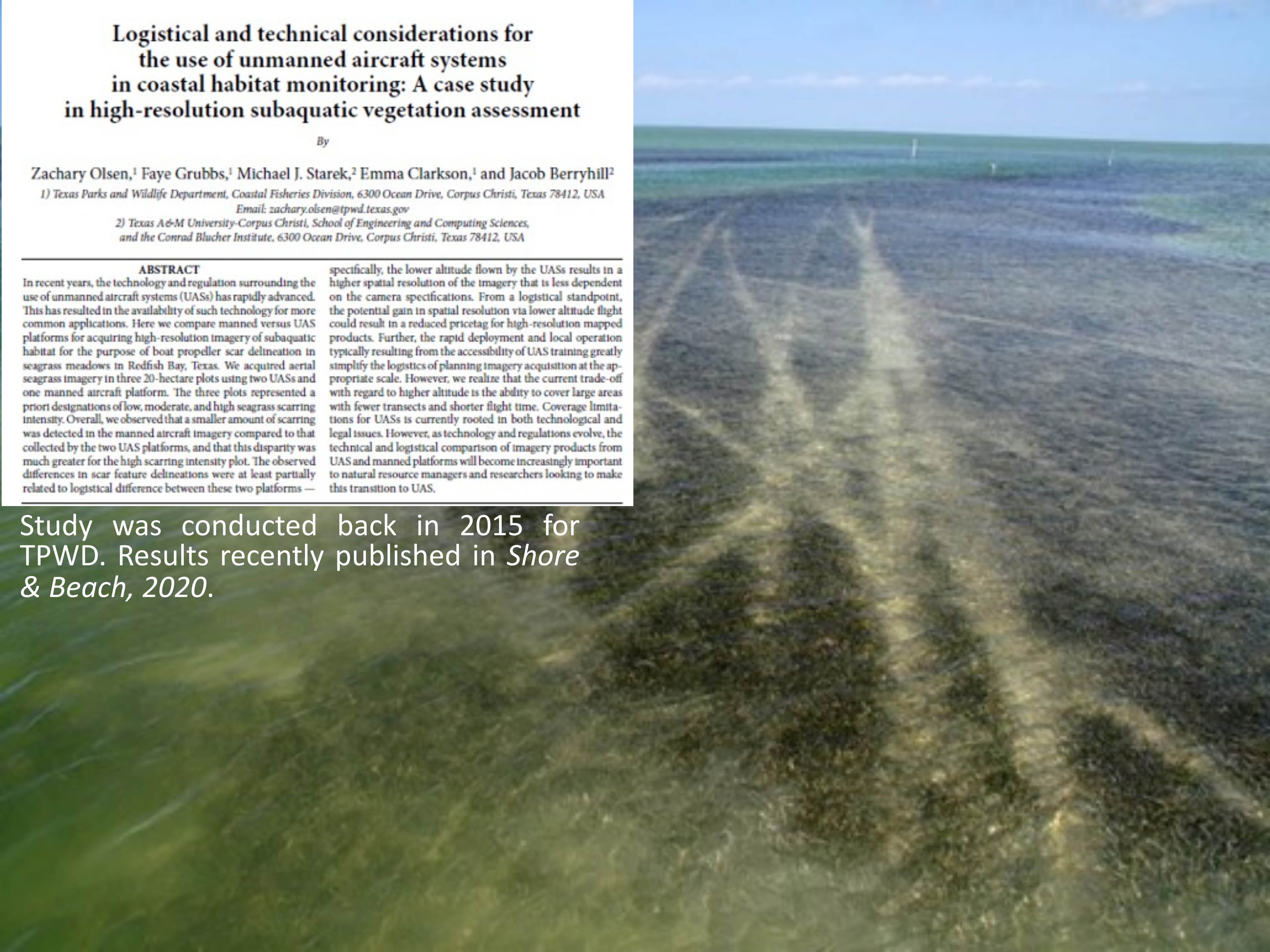
Image Time Stack (Timex) for cBathy Algorithm



Depth Estimated Map



Research in progress by TAMUCC MS student Larissa Freguete



Logistical and technical considerations for the use of unmanned aircraft systems in coastal habitat monitoring: A case study in high-resolution subaquatic vegetation assessment

By

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2) Texas A&M University-Corpus Christi, School of Engineering and Computing Sciences, and the Conrad Blucher Institute, 6300 Ocean Drive, Corpus Christi, Texas 78412, USA

ABSTRACT

In recent years, the technology and regulation surrounding the use of unmanned aircraft systems (UASs) has rapidly advanced. This has resulted in the availability of such technology for more common applications. Here we compare manned versus UAS platforms for acquiring high-resolution imagery of subaquatic habitat for the purpose of boat propeller scar delineation in seagrass meadows in Redfish Bay, Texas. We acquired aerial seagrass imagery in three 20-hectare plots using two UASs and one manned aircraft platform. The three plots represented a priori designations of low, moderate, and high seagrass scarring intensity. Overall, we observed that a smaller amount of scarring was detected in the manned aircraft imagery compared to that collected by the two UAS platforms, and that this disparity was much greater for the high scarring intensity plot. The observed differences in scar feature delineations were at least partially related to logistical difference between these two platforms — specifically, the lower altitude flown by the UASs results in a higher spatial resolution of the imagery that is less dependent on the camera specifications. From a logistical standpoint, the potential gain in spatial resolution via lower altitude flight could result in a reduced pricetag for high-resolution mapped products. Further, the rapid deployment and local operation typically resulting from the accessibility of UAS training greatly simplify the logistics of planning imagery acquisition at the appropriate scale. However, we realize that the current trade-off with regard to higher altitude is the ability to cover large areas with fewer transects and shorter flight time. Coverage limitations for UASs is currently rooted in both technological and legal issues. However, as technology and regulations evolve, the technical and logistical comparison of imagery products from UAS and manned platforms will become increasingly important to natural resource managers and researchers looking to make this transition to UAS.

Study was conducted back in 2015 for TPWD. Results recently published in *Shore & Beach, 2020*.

Open Access Article

Deep Learning-Based Single Image Super-Resolution: An Investigation for Dense Scene Reconstruction with UAS Photogrammetry

by Mohammad Pashaei [1,2], Michael J. Starek [1,2,*], Hamid Kamangir [2] and Jacob Berryhill [2]

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Remote Sens. **2020**, *12*(11), 1757; https://doi.org/10.3390/rs12111757

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(a) LR

(b) SR_{pre}

(c) HR_{enh}

(d) HR_{gt}

Thank you SCOAR!

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