# Coastal Imaging of Morphology

Katherine Brodie[1], Margaret Palmsten[2], Jenna Long[3], and Brittany Bruder[1]

[1] U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Duck, NC

[2] U.S. Naval Research Laboratory, Stennis Space Center, MS

[3] U.S. Geological Society, Coastal Marine Science Center, St. Petersburg, FL

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SECOORA Southeast Coastal Ocean Observing Regional Association

IOOS Integrated Ocean Observing System

# Ground-based Coastal Imaging History

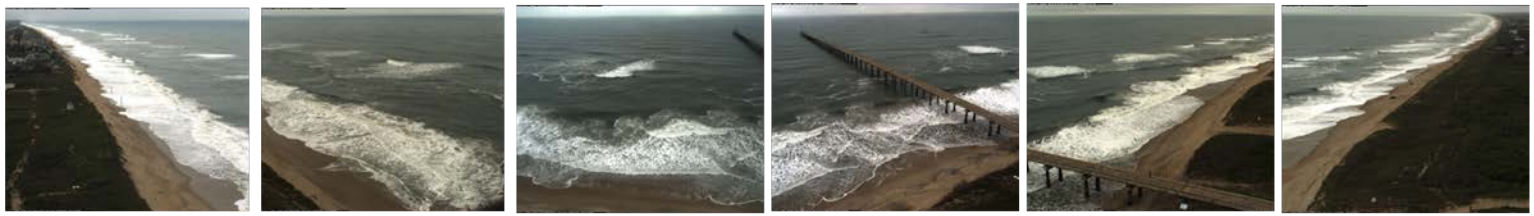
- 1910s: Aerial photography & traditional photogrammetry
- 1980s: Time-averaged photography
- 1990s-2000s: Development of a global Argus network w/ automated data products

- 2010 – Present: easy access to action cameras, streaming web-cameras, and drone/UAV-based cameras

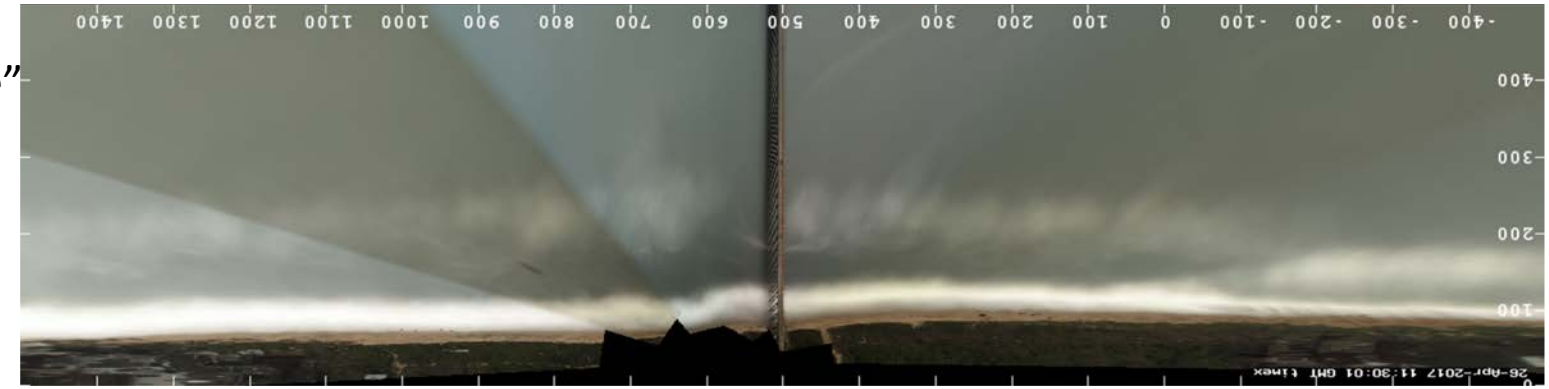
# Basics of Photogrammetry

- With a few pieces of information we can exploit how a camera lens works to make quantitative measurements within the camera field of view

"Oblique Image" (pixel space)



"Projected Image" (geo-rectified maps; can make spatial measurements)



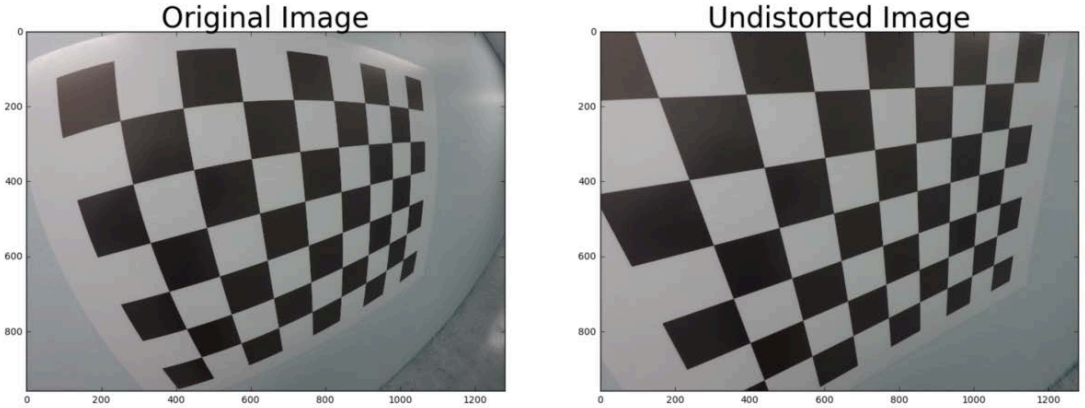
# Camera Basics

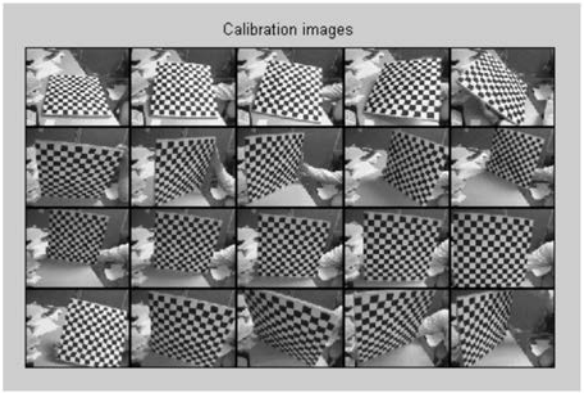
- **Lens** → focal length determines field of view (FOV)
- **Sensor Size** → controls image dimension, noise level, and the number of pixels in your image (image resolution)
- **Frame Rate** → controls the frequency of your pictures
- **Shutter Type** → rolling shutters (most webcams) will look like "jello" if shaking (high-wind)
- **Exposure** → changes to the shutter speed, aperture, and ISO based on light fluctuations effect the brightness of features in your images (fixed vs. auto-adjusting)

# Basics of Photogrammetry

- Camera “Intrinsics” or “Interior parameters” (lens distortion)

Distorted → Undistorted




Taking pictures of objects of known size (like a checkerboard) allows us to solve the distortion coefficients

## Take Home Points:

- Simple calibration to determine distortion coefficients is needed to remove lens effects (must always do!)
- The wider your field-of-view, the more distorted your imagery and the more spatial variability in your ground sample distance (size of a pixel in the real world)

# Basics of Photogrammetry

- Camera “Extrinsics” or “Exterior parameters” (position & orientation)

Position: X, Y, Z of camera
Orientation: Heading, Roll, Pitch

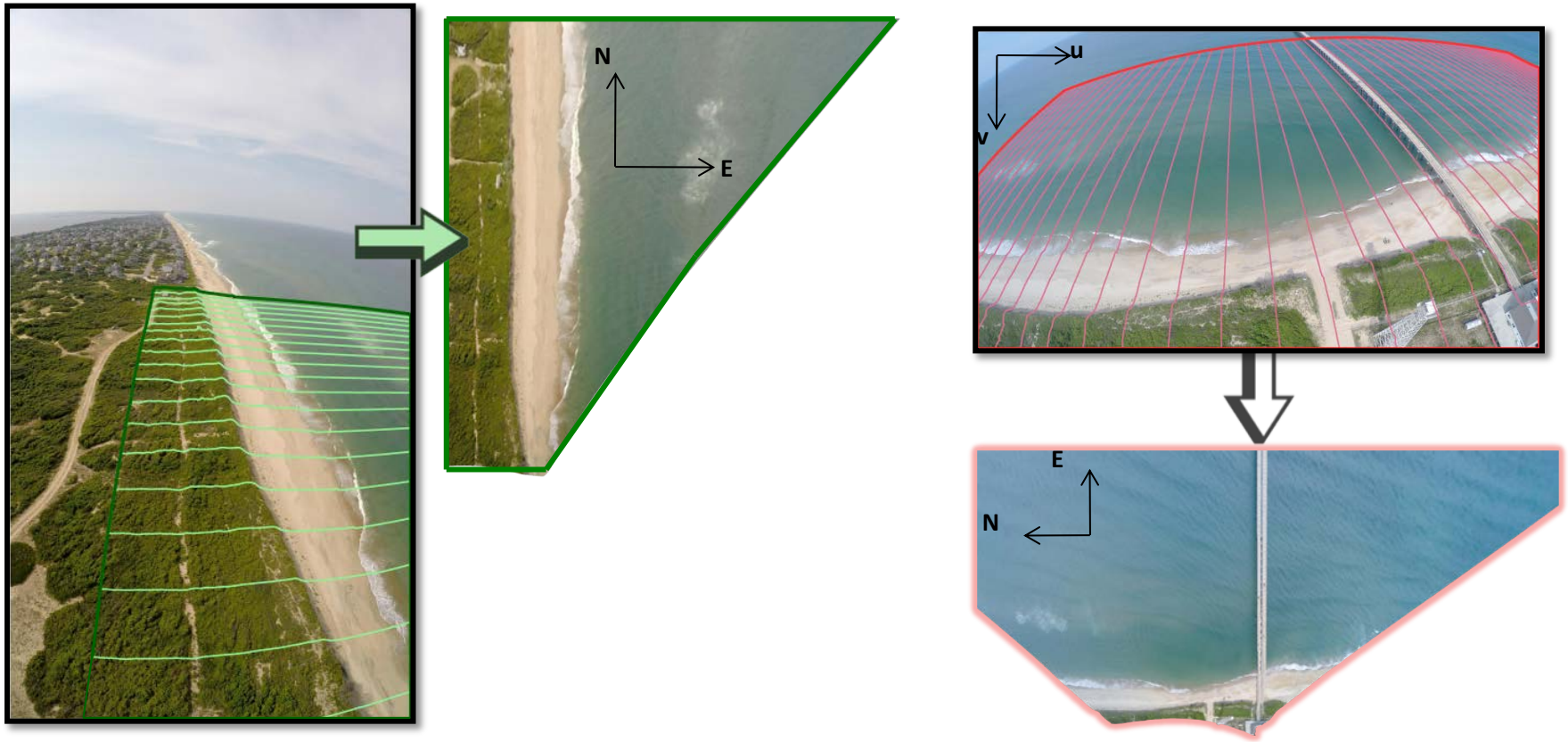
- Sometimes these can be difficult to measure;
- instead we use Ground Control Points (GCP)s, and survey their location to solve for position and orientation


## Take Home Points:

- Critical for making maps with your images
- Need known features (at least 4 GCPs; more is better) in FOV and must have a good distribution of GCPs throughout your FOV
- Need to re-do every time camera moves OR use a correction algorithm to match features between images to remove movement

# Basics of Photogrammetry

- Image projection uses intrinsics & extrinsics in combination with known topography to rectify the image into map space



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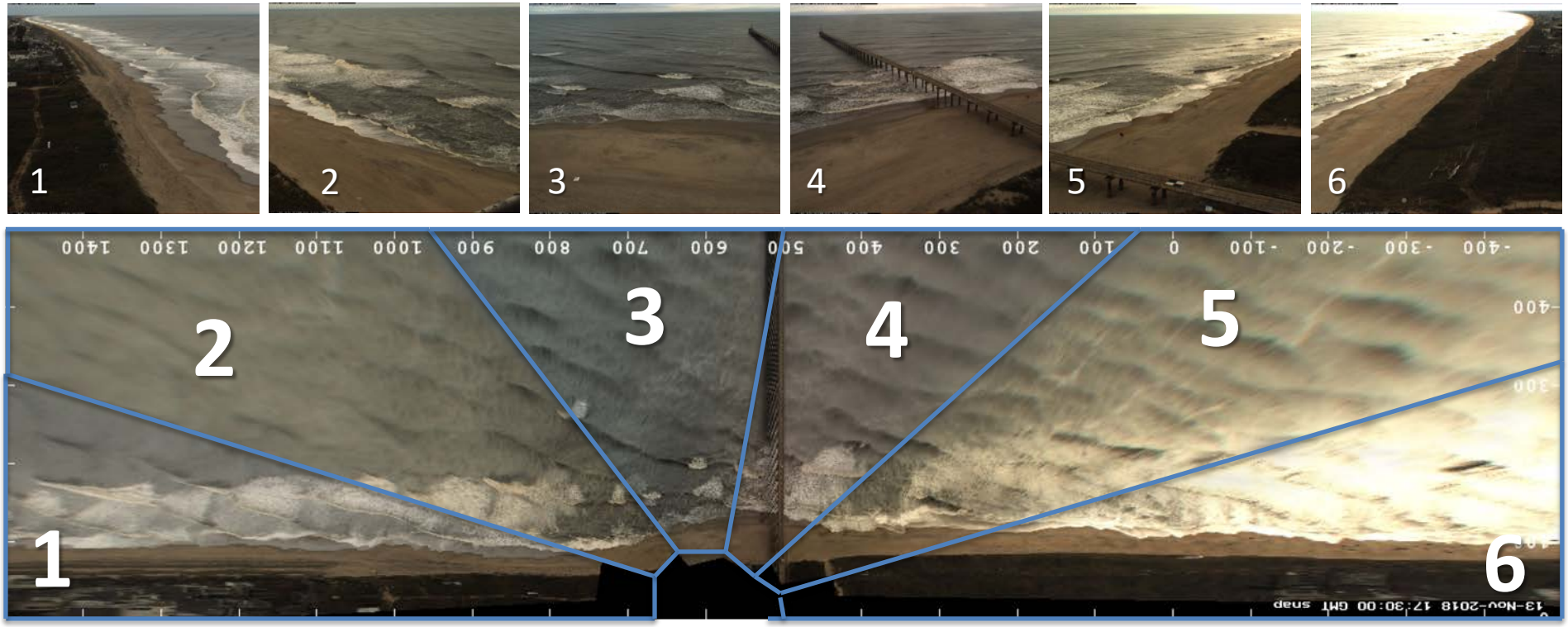
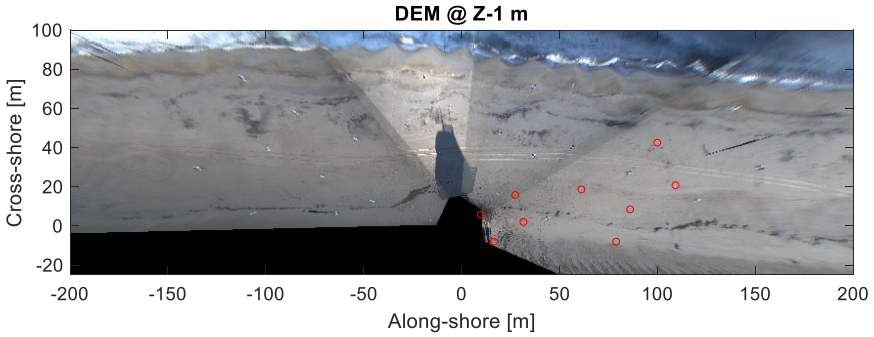
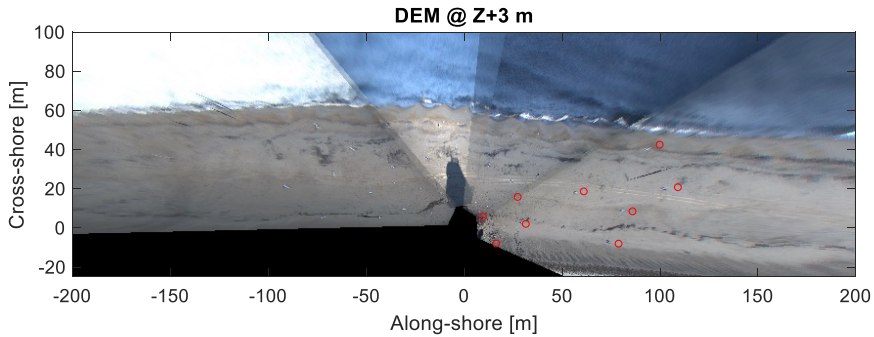


# Basics of Photogrammetry

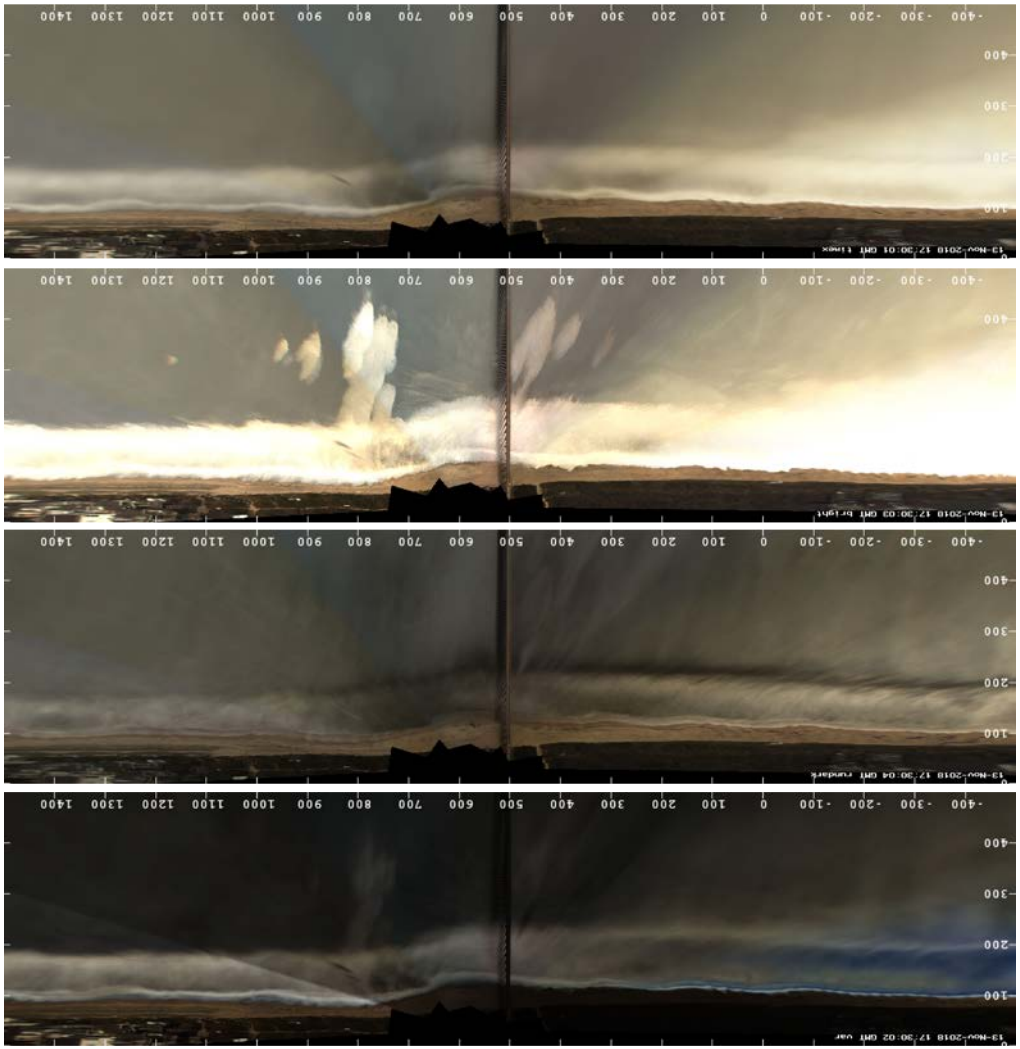
- → Sometimes we don't "know" the topography (particularly in coastal environments because it changes so quickly):
  - → can use tide elevation as water elevation
  - → can use "idealized" beach profile as topography
  - → can update topography when new surveys are completed (e.g. lidar data)
- → Above suggestions introduce some error in relative measurements;
- → This error is less important the higher your camera is (looking closer to straight down)




→ Apparent shoreline position shifts if use different topography

# Coastal Morphology



**Time-average**:
wave breaking locations (and not breaking…e.g. rips)

**Brightest**:
Shoreline inundation (runup)
Set breakpoint locations
Tracking bright objects (birds?)

**Darkest**:
Tracking dark objects (people on beach); wild-life?
Wave shoaling region

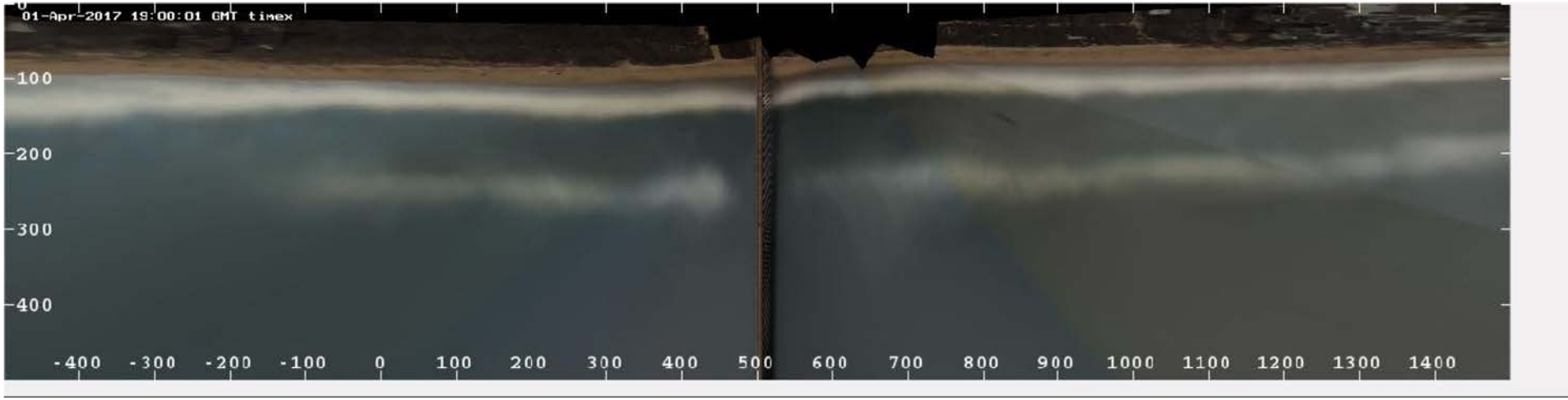
**Variance**:
Highlights regions that change frequently

# Example Application: Maximum Runup Position


- Brightest image can quantify how often runup reaches a certain position on the beach;
- Average dry beach width (important for dune building)

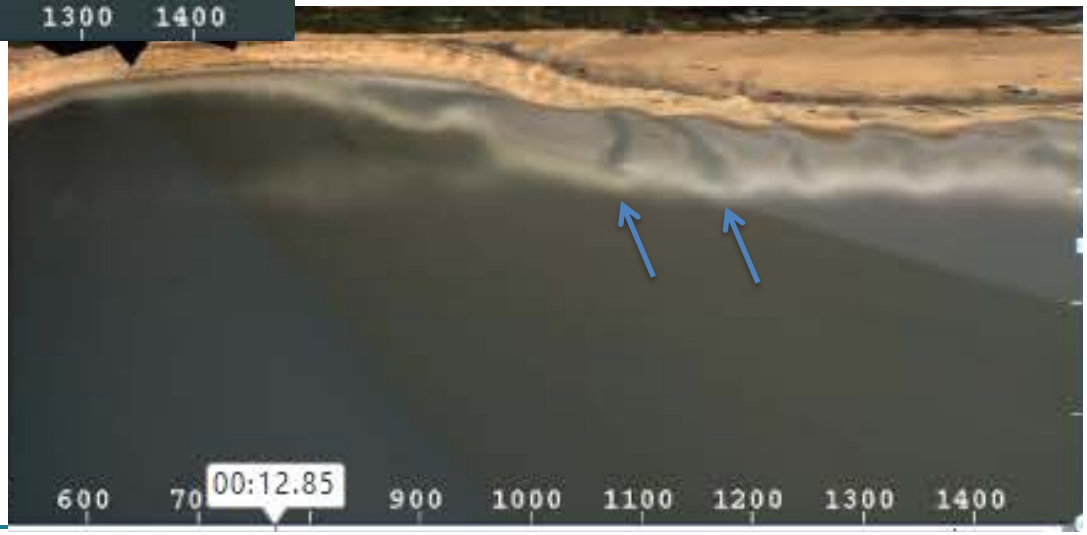
# Example Application: Beach Nourishment Evolution

- Building and evolution of the Duck Beach Nourishment (Summer 2017)



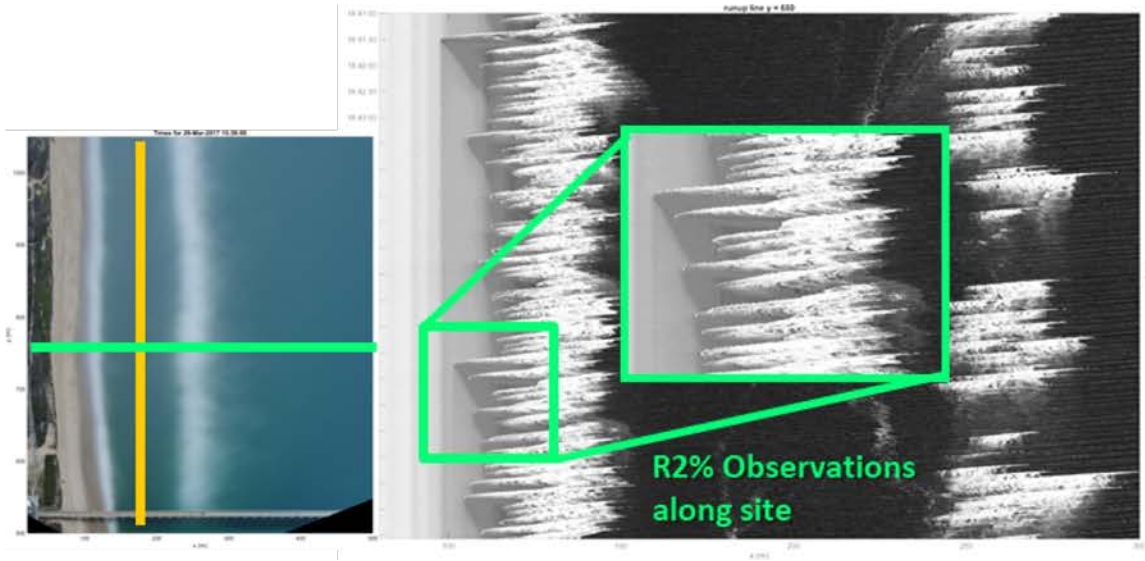
# Example Application: Rip Currents

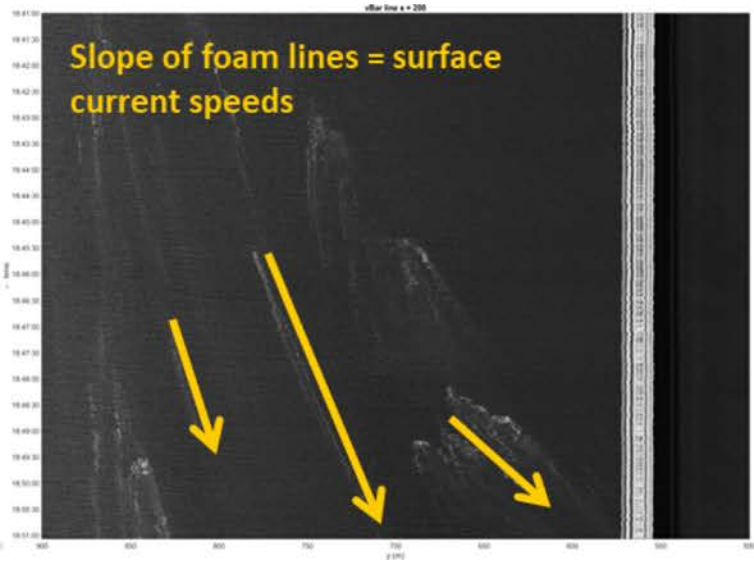

Persistent areas of no wave breaking can be associated with rip currents



# Example Application: Hydrodynamics

- By doing time-series analysis on videos, can quantify:
  - Current magnitudes & directions from tracking foam
  - Wave runup spectra
  - Wave breaking percentage, etc.

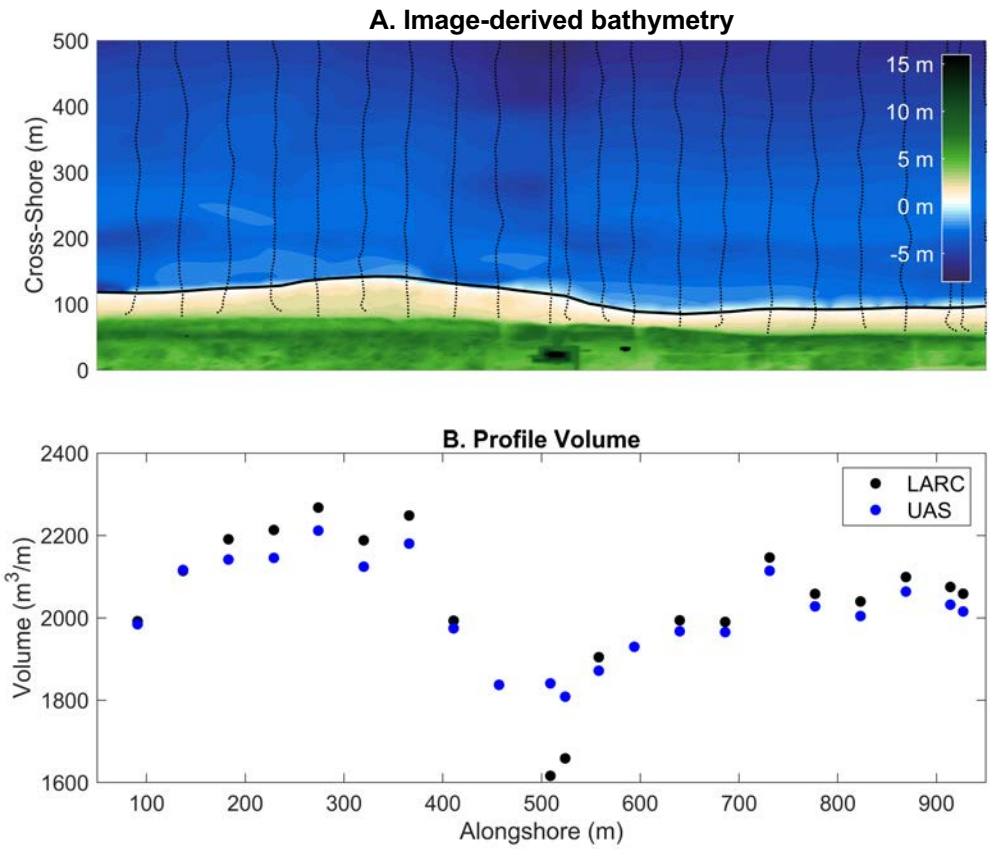


# Example Application: Bathymetry

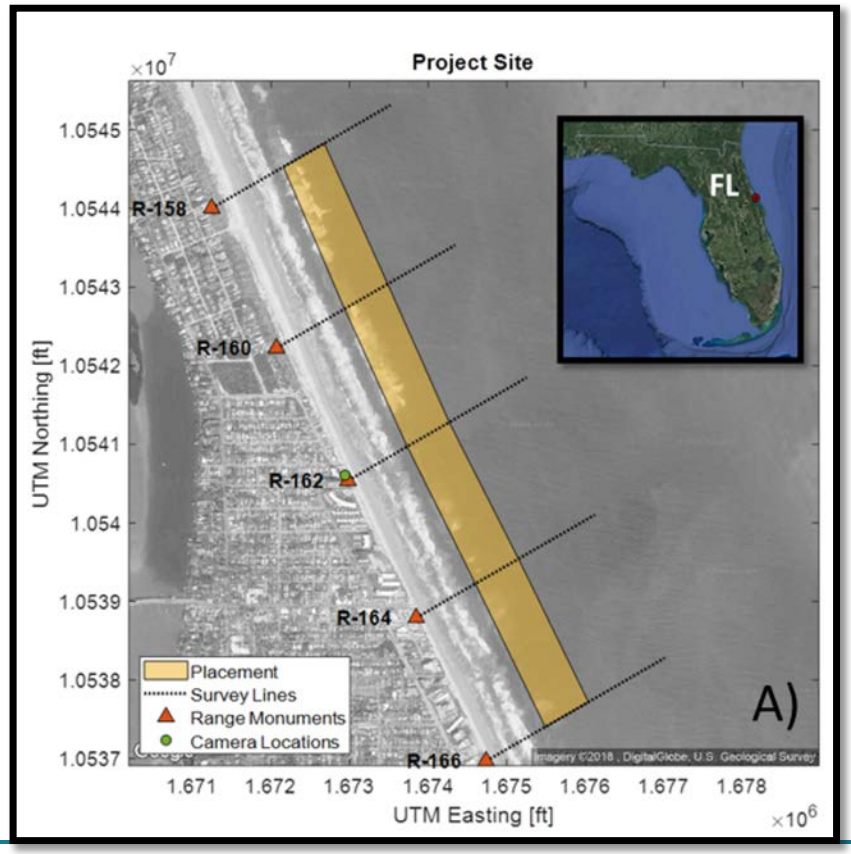
- Can use spectral analysis techniques to measure the speed of waves, and from that wave speed calculate water depth

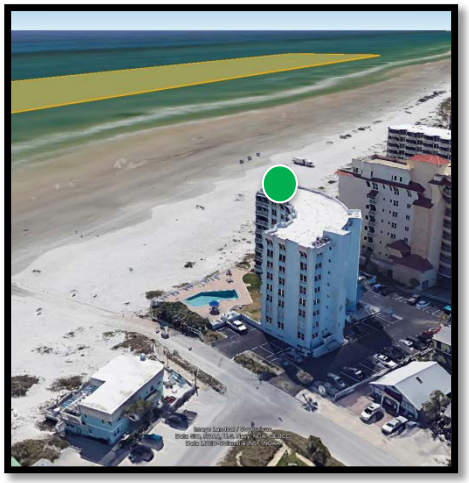
- Accuracy is dependent on wave conditions (less breaking = more accurate)



# Example USACE Interests

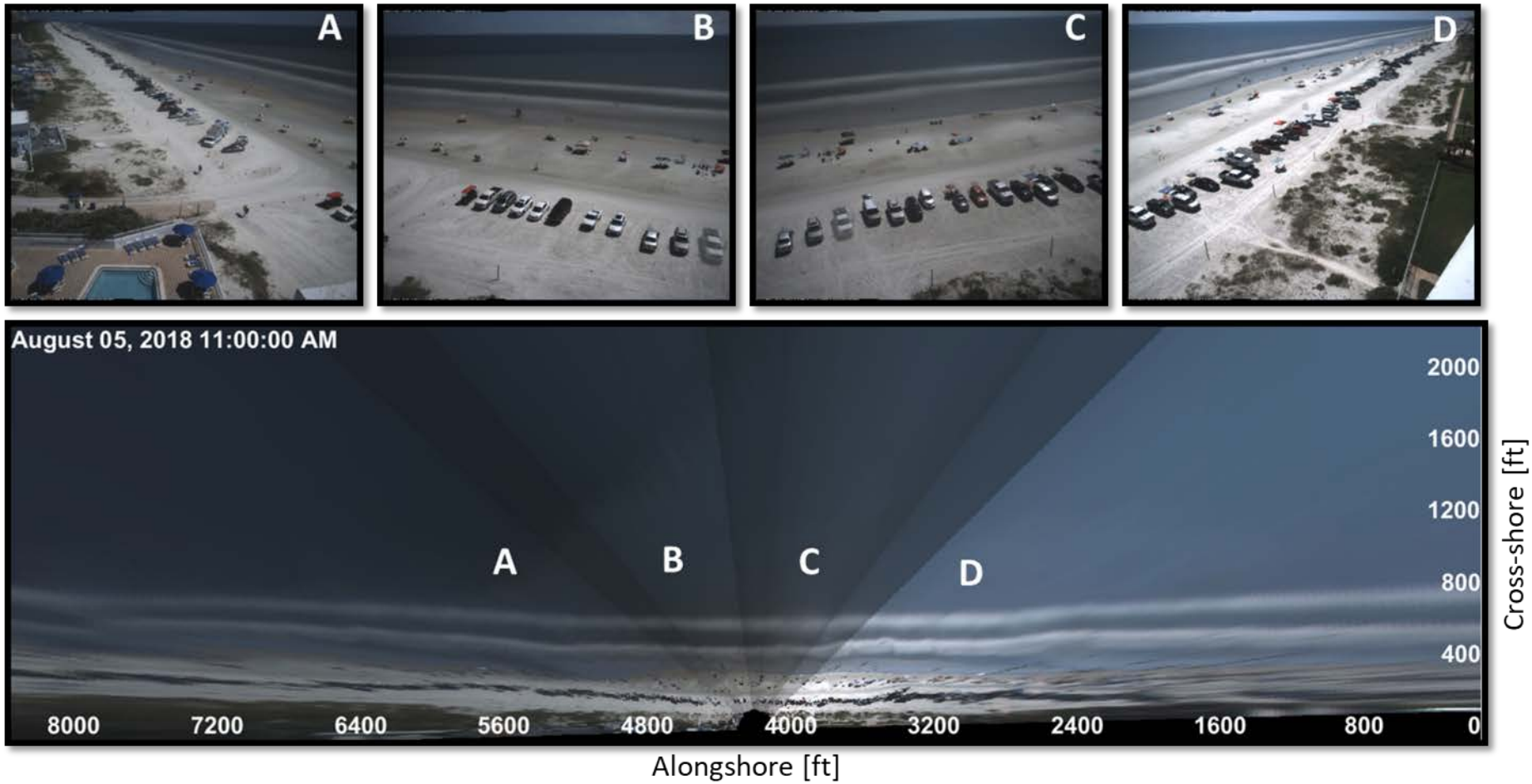
- Monitor a nearshore berm placement, New Smyrna, FL



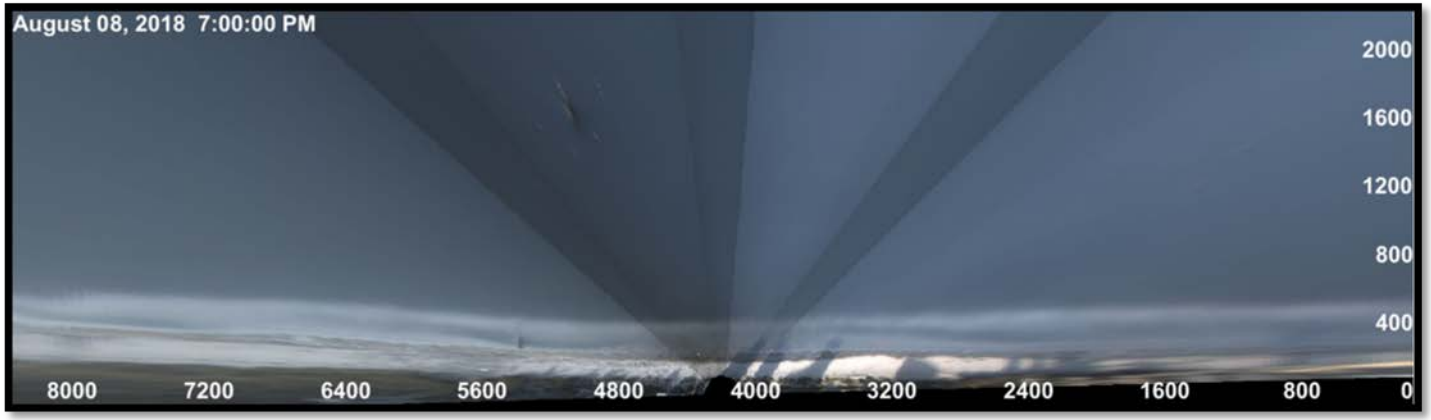
Mounted cameras on condo

# Example USACE Interests

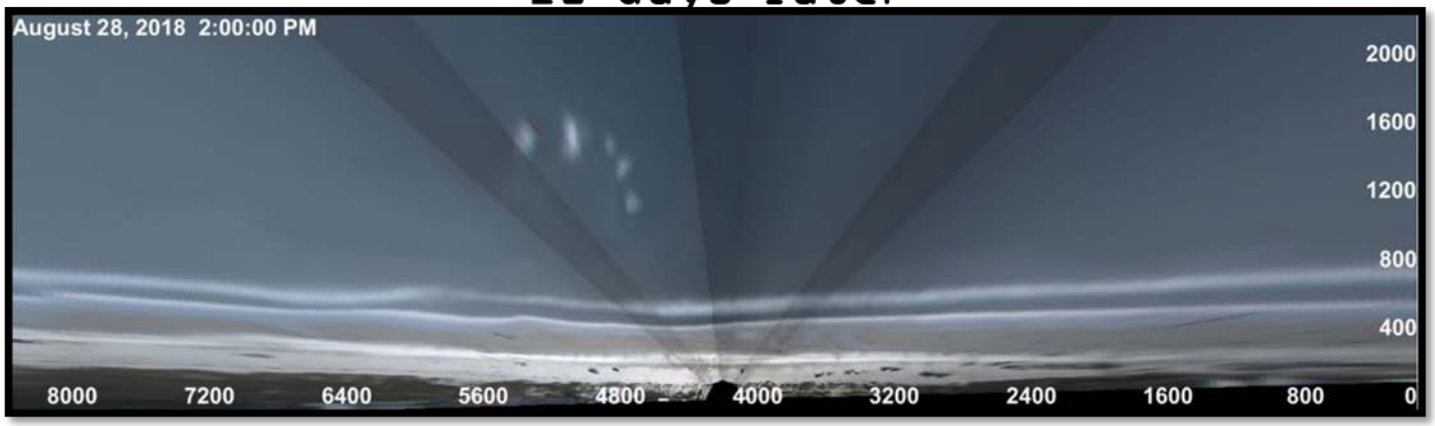


# Example USACE Interests

Project start

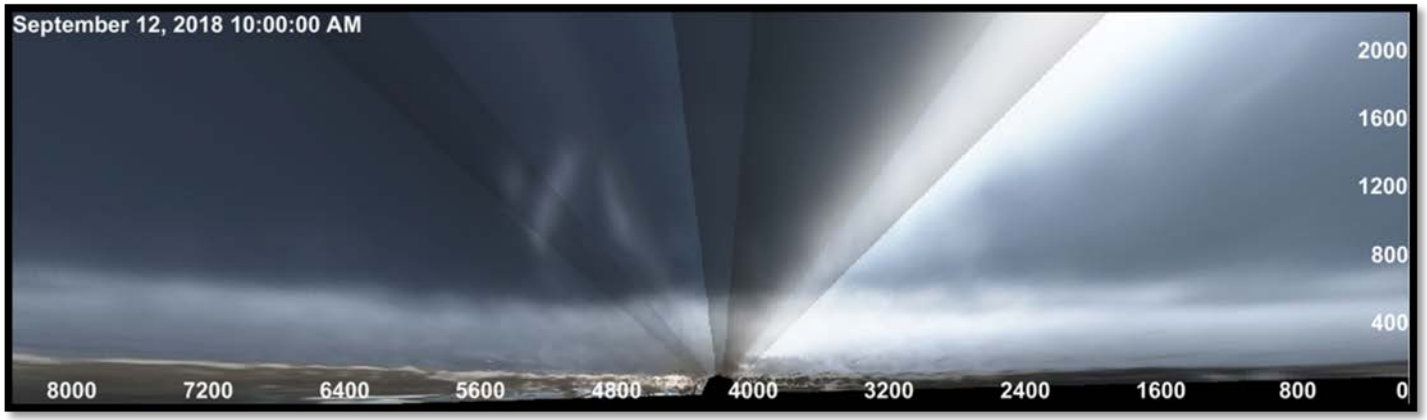



20 days later

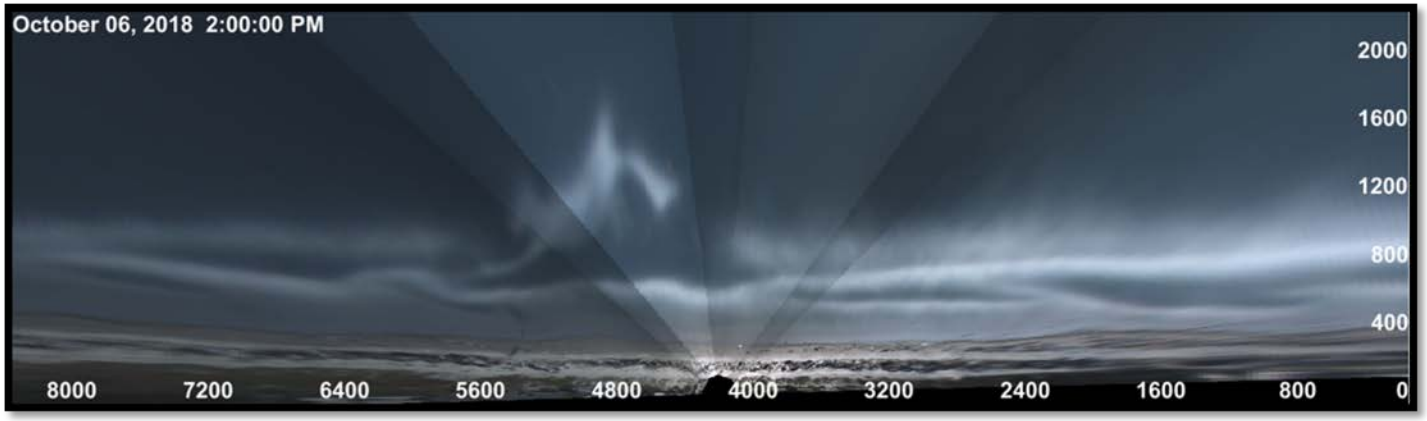


# Example USACE Interests

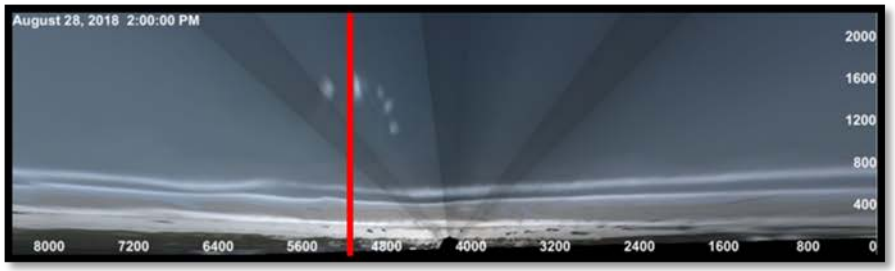
Hurricane Florence



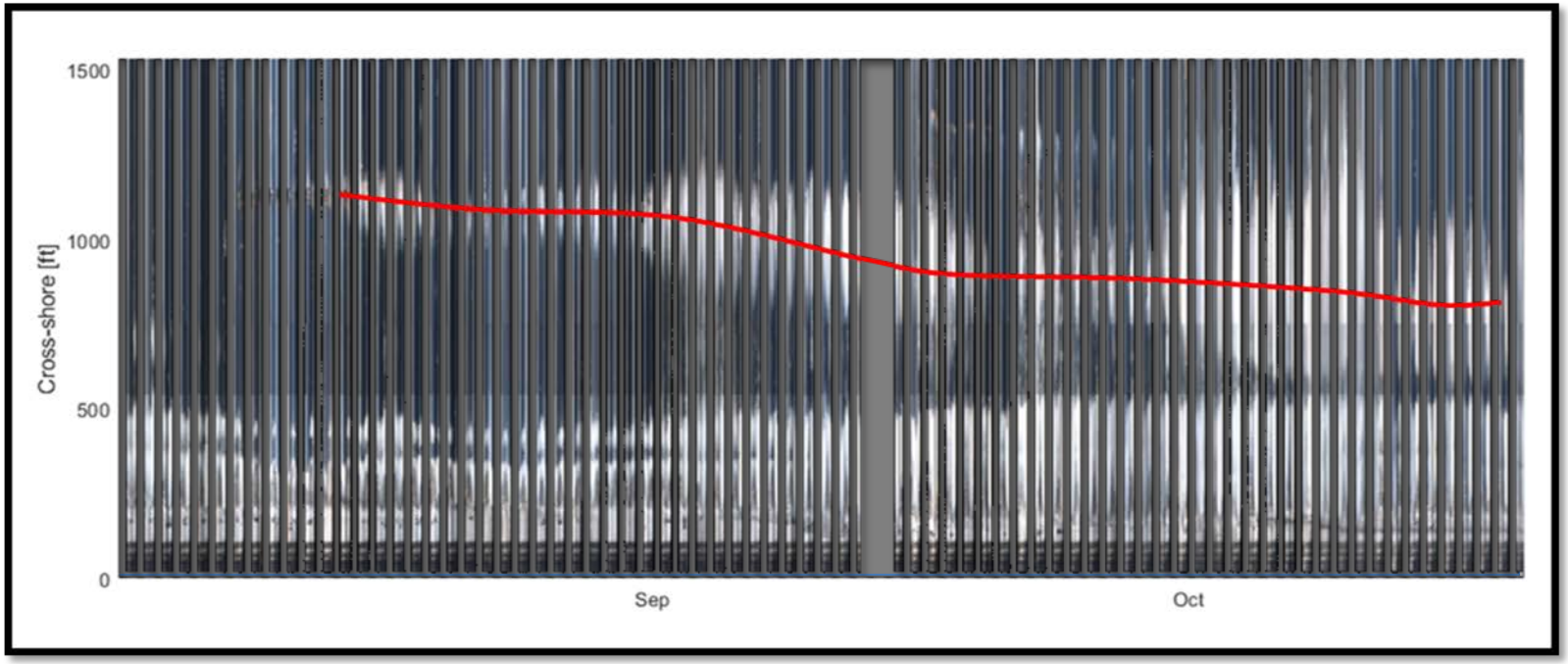

Hurricane Michael



# Example USACE Interests

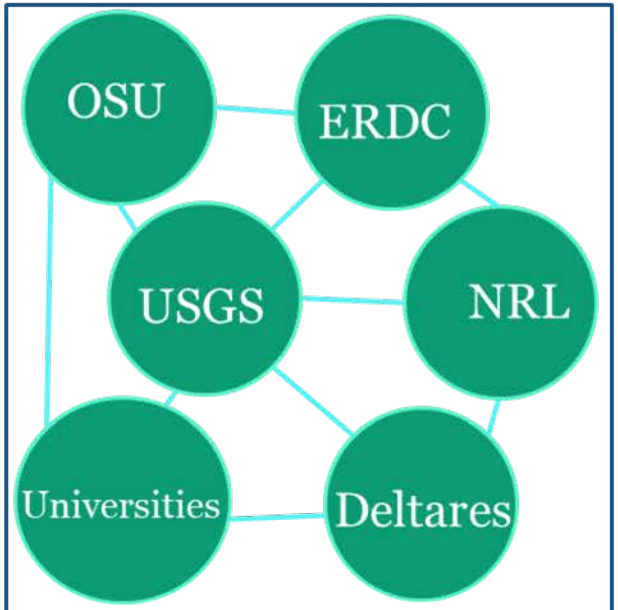



Nearshore berm onshore migration



# Coastal Imaging Research Network

- Increase Growth, Applications, and Knowledge of the Community




- Distributed approach
- More collaboration
- Shared resources
- Learning opportunities


- Open source
- Version control
- Wiki
- DIY camera systems
- Social media/Forum

**I**nternational
**C**oastline
**O**bservatory
**N**etwork

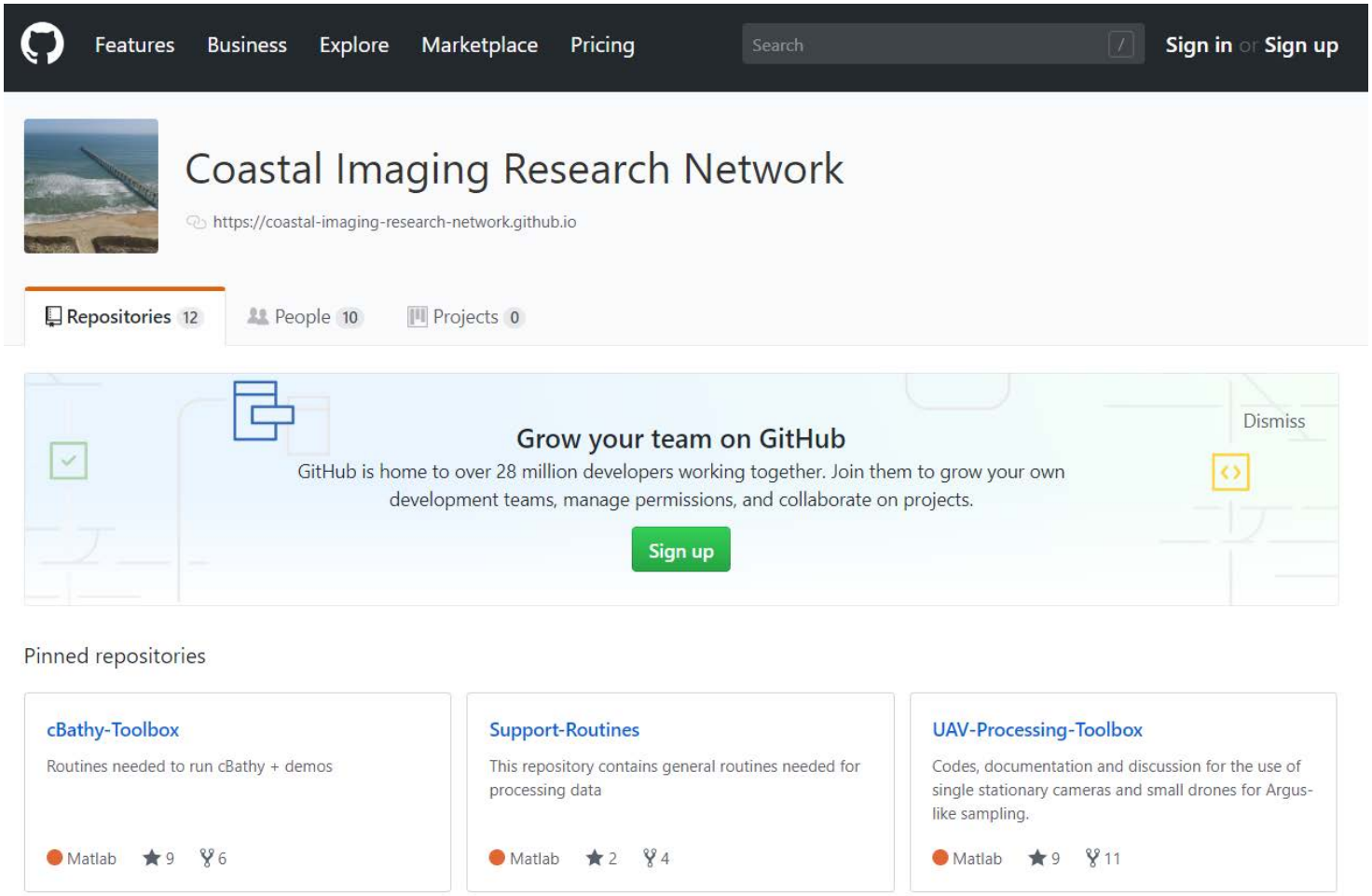
- Long term monitoring
- Open source data

# Coastal Imaging Research Network

https://coastal-imaging-research-network.github.io

# Coastal Imaging Research Network

https://github.com/Coastal-Imaging-Research-Network



# Coastal Imaging Research Network

- Upcoming Coding Bootcamps
  - @ Coastal Sediments Conference, St. Petersburg, FL (27 May)
  - @ 2018 CIRN Workshop in Toulouse, FR (17-18 June)

- Upcoming CIRN Workshops
  - Toulouse, France (19-21 June 2019)
  - Duck, NC (May 2020)

# Questions?

SECOORA
Southeast Coastal Ocean Observing Regional Association

IOOS
Integrated Ocean Observing System

www.secoora.org/webcat