Quantifying Dune Morphological Evolution on Storm to Annual Time Scales

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CIRP Research & Development — Mission Support, Technology Transfer

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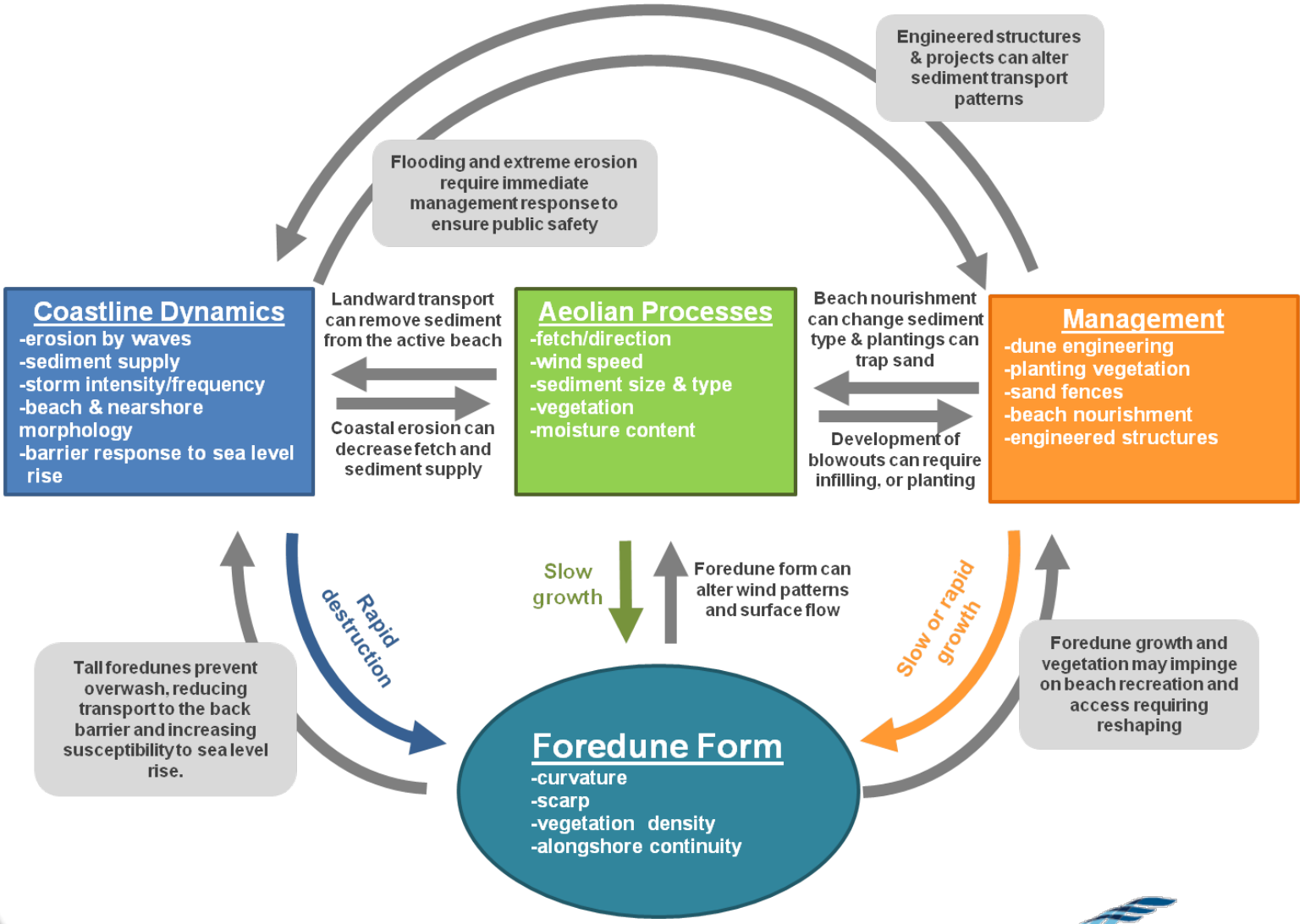
Motivation & Research Questions

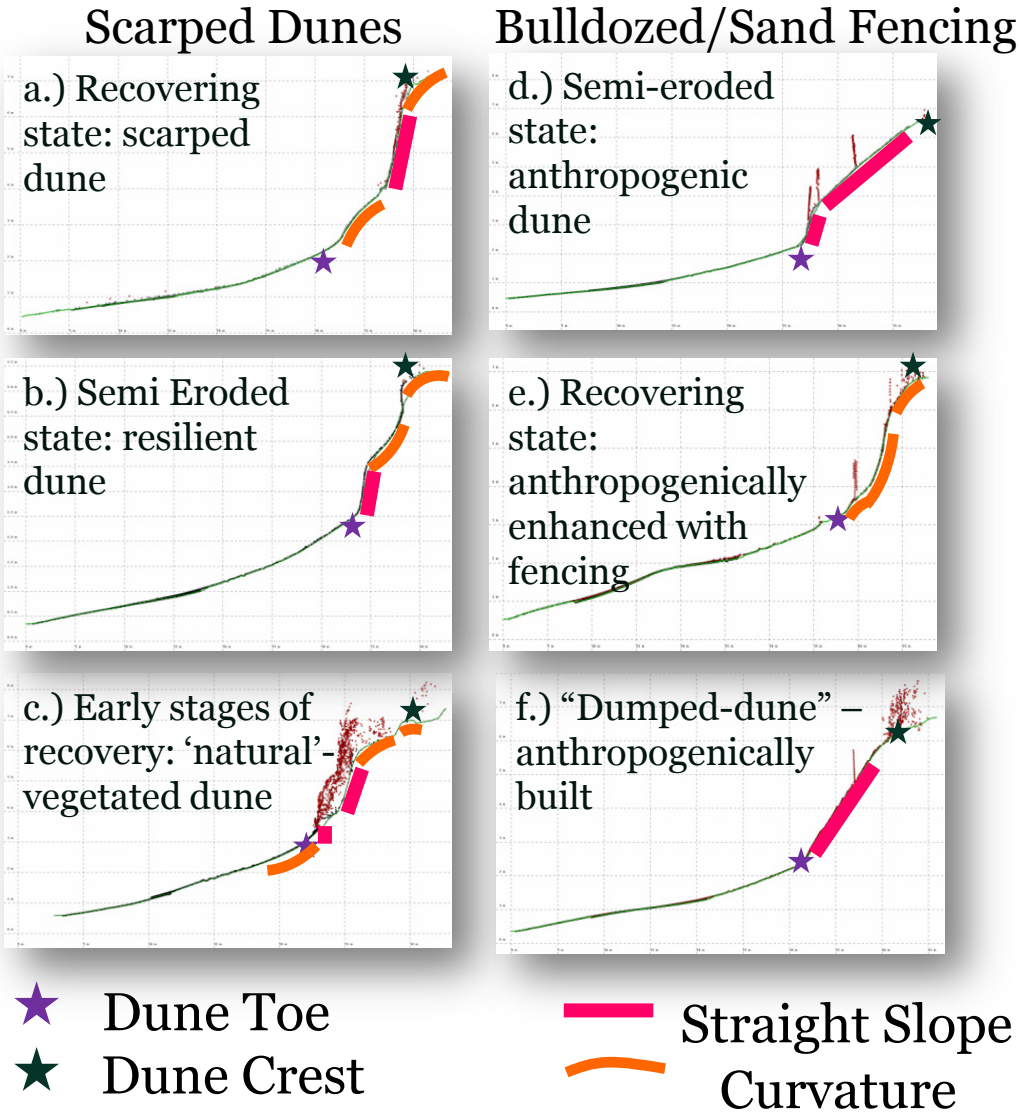
- Importance of dunes as nature-based infrastructure that can offer protection during storms
- How can we better utilize dense lidar data sets to identify the physical processes acting on a dune?
- How does dune morphology affect rates of erosion during a storm?
- Can we better quantify (and ultimately predict) rates of natural dune recovery?

Foredune Evolution



Swann, C., Brodie, K.L. and Spore, N. 2015 Coastal Foredunes: Identifying coastal, aeolian and management interactions driving morphologic state change. Technical Report No. ERDC/CHL TR-15-XX. Vicksburg MS: U.S. Army Engineer Waterways Experiment Station.

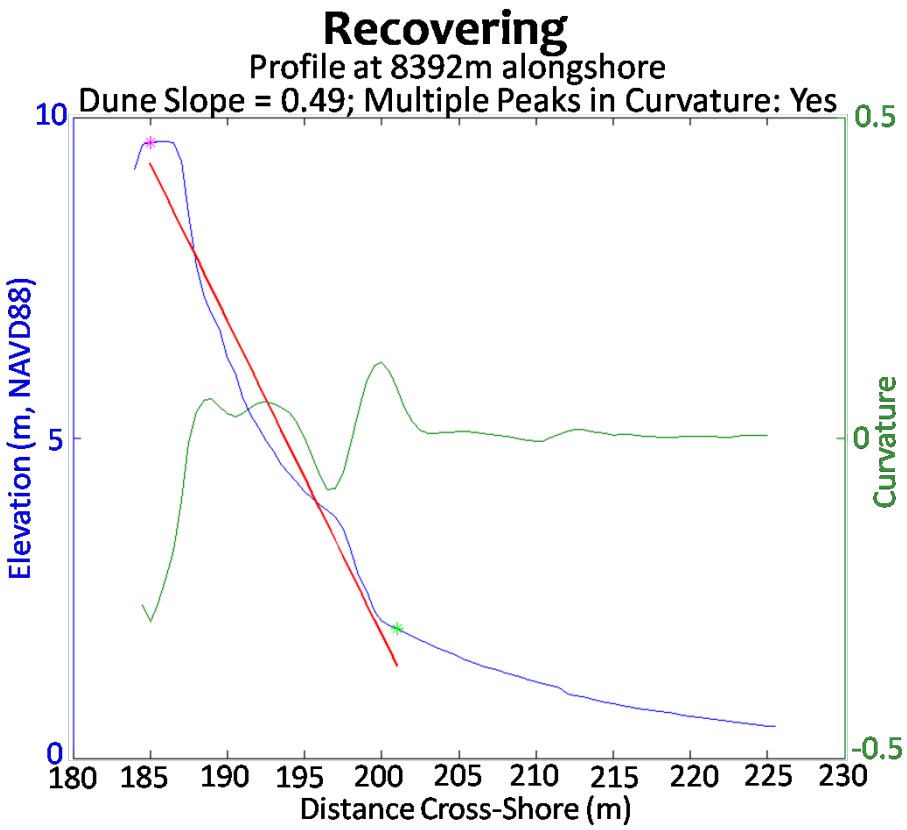
Foredune Form

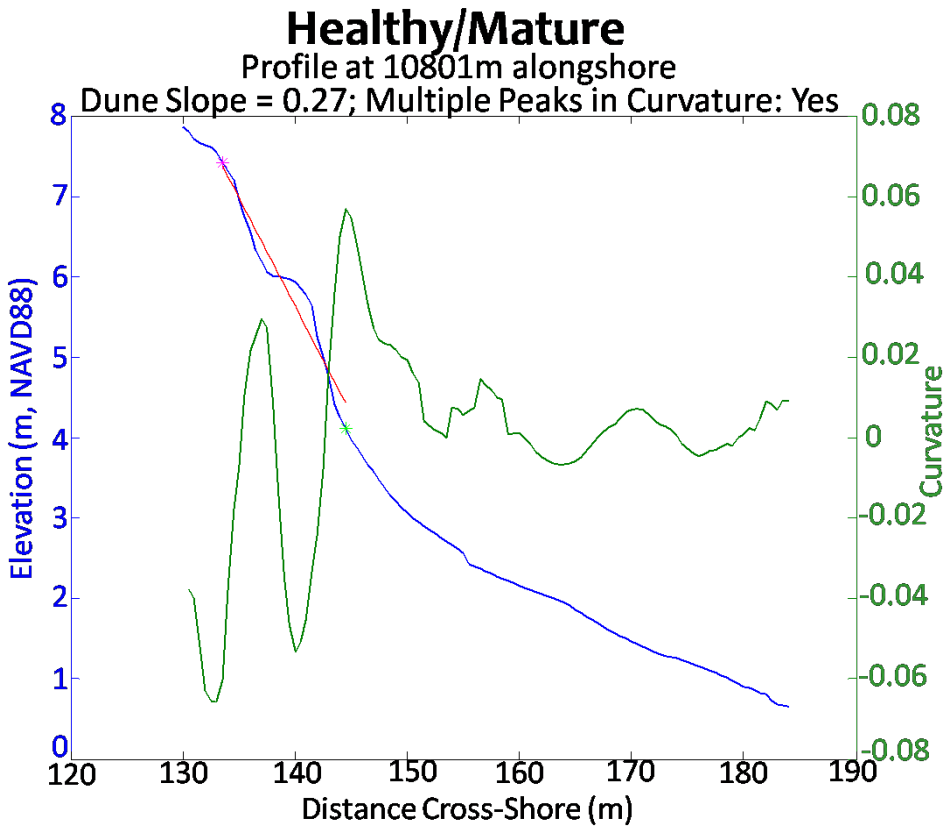


- If the physical processes acting on a dune affect its morphology, can we use detailed morphological observations to better quantify the present state of a dune?
- Problem:
  - Dense lidar datasets are often under-utilized because users are often CPU & time limited
- Solution:
  - Develop automated tools to analyze & classify dune state

Coastal Foredune State

- Convex curvature indicative of active Aeolian processes (Thom and Hall, 1991)



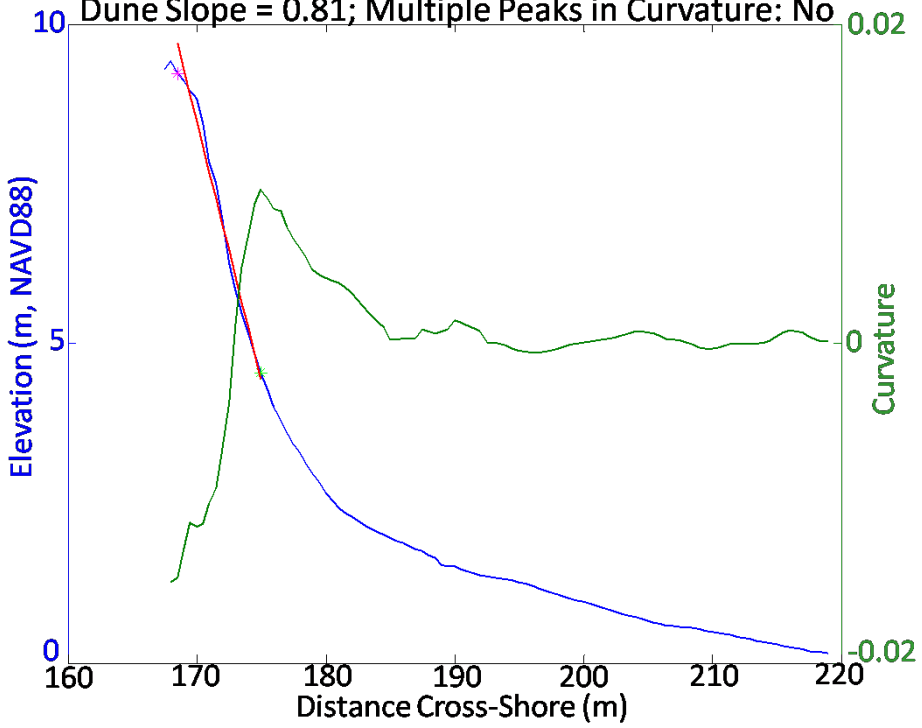


- Incipient dune forms near dune toe (Hesp 2002) while upper dune face remains steep indicating recent wave attack
- Prograding dune with high volume and shallower slopes closer to the angle of repose

Brodie, K.L. and Spore, N.J. (2015). **FOREDUNE CLASSIFICATION AND STORM RESPONSE: AUTOMATED ANALYSIS OF TERRESTRIAL LIDAR DEMS.** Proceedings of Coastal Sediments 2015, San Diego, California.

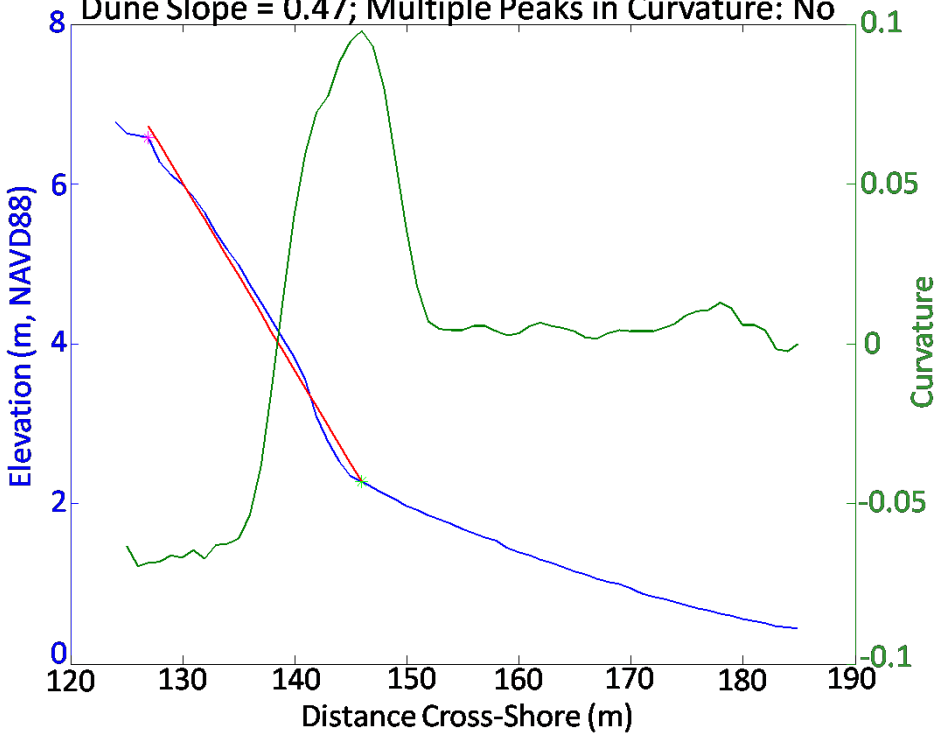
Coastal Foredune State

Scarped



- Defined by steep slopes and low dune volume, indicative of recent scarping from wave attack
- No incipient dune present and often little to no recovery at the base of the dune

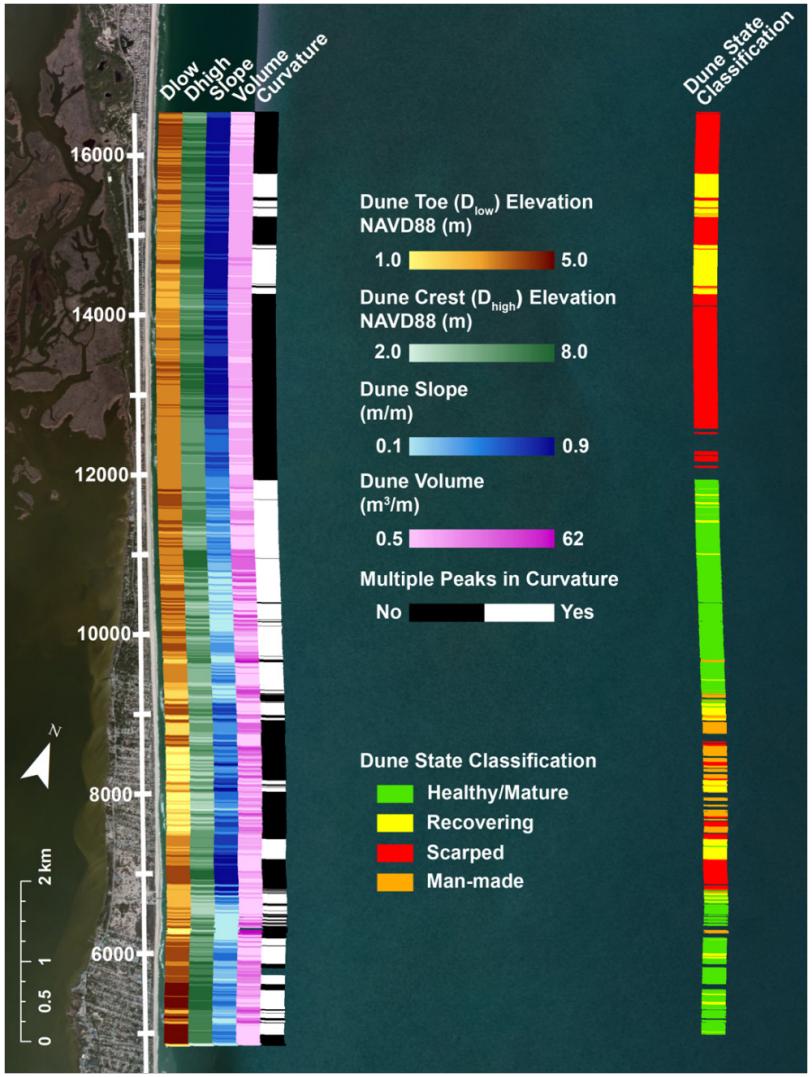
Man-made



- Larger dune volume and shallower slope approaching angle of repose typically placed as an unconsolidated pile of sediment

Brodie, K.L. and Spore, N.J. (2015). **FOREDUNE CLASSIFICATION AND STORM RESPONSE: AUTOMATED ANALYSIS OF TERRESTRIAL LIDAR DEMS.** Proceedings of Coastal Sediments 2015, San Diego, California.

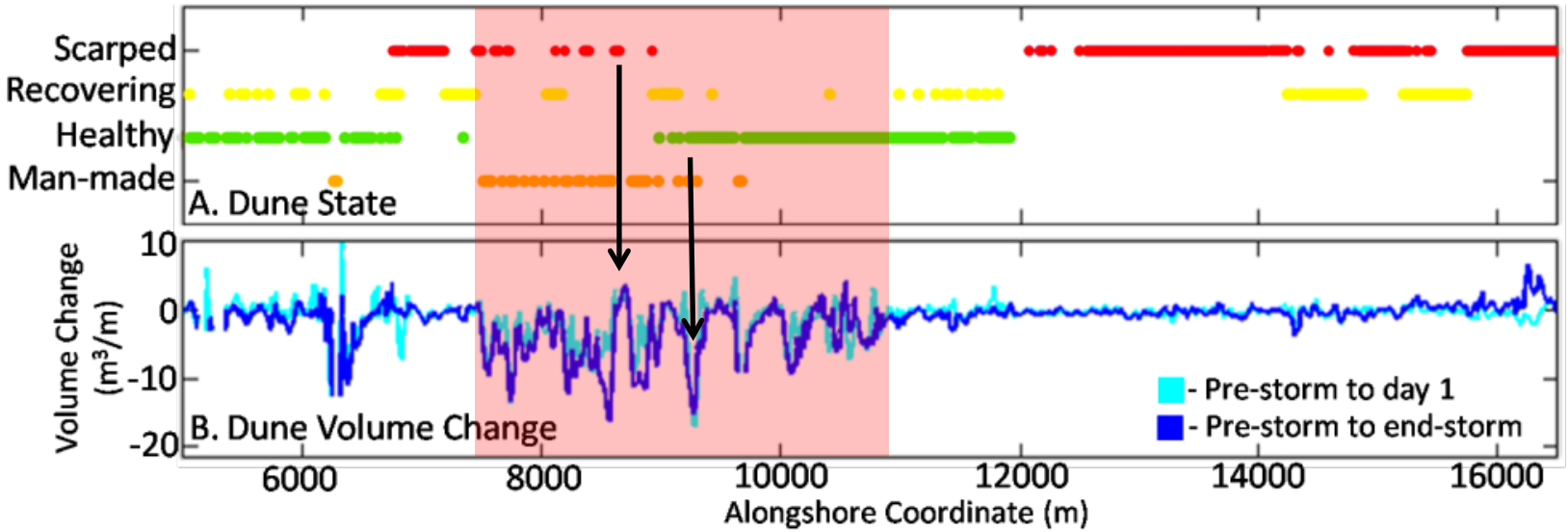
Coastal Foredune State

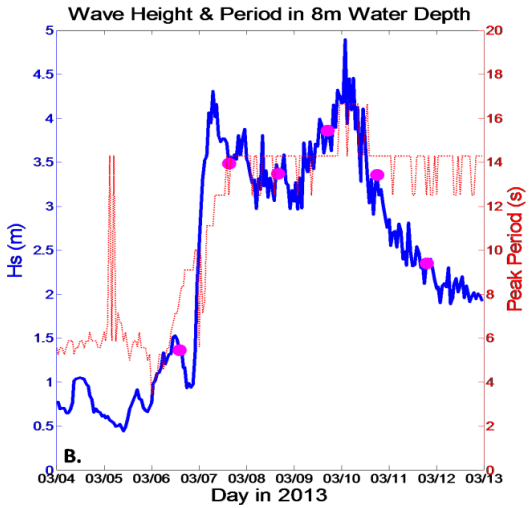


- Automated analysis that classifies foredune state from terrestrial lidar DEMs
- Classification can help identify regions of the coastline that are:
  - recovering naturally
  - remaining in an erosive state

Brodie, K.L. and Spore, N.J. (2015). **FOREDUNE CLASSIFICATION AND STORM RESPONSE: AUTOMATED ANALYSIS OF TERRESTRIAL LIDAR DEMS.** Proceedings of Coastal Sediments 2015, San Diego, California.

Dune Response during a Nor'Easter





- Relationship between pre-storm dune state & magnitude of response?
- Do unconsolidated, new, man-made dunes erode more rapidly that natural dunes?

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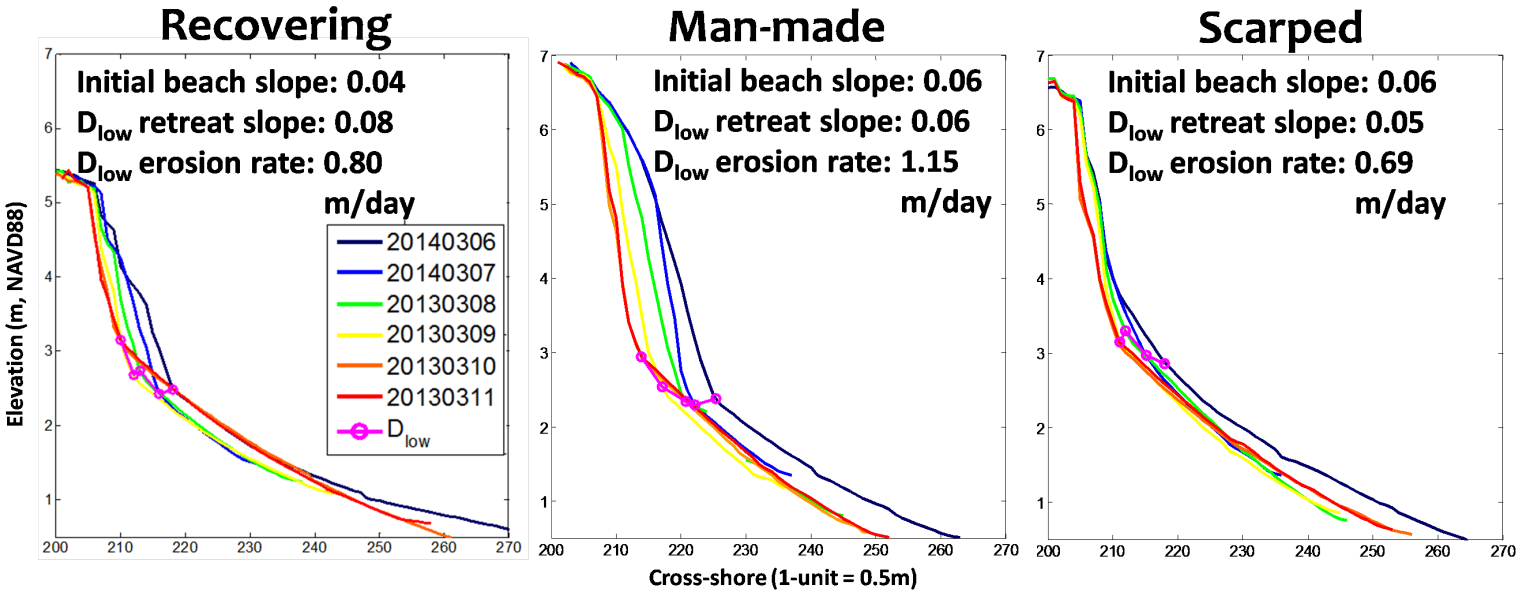
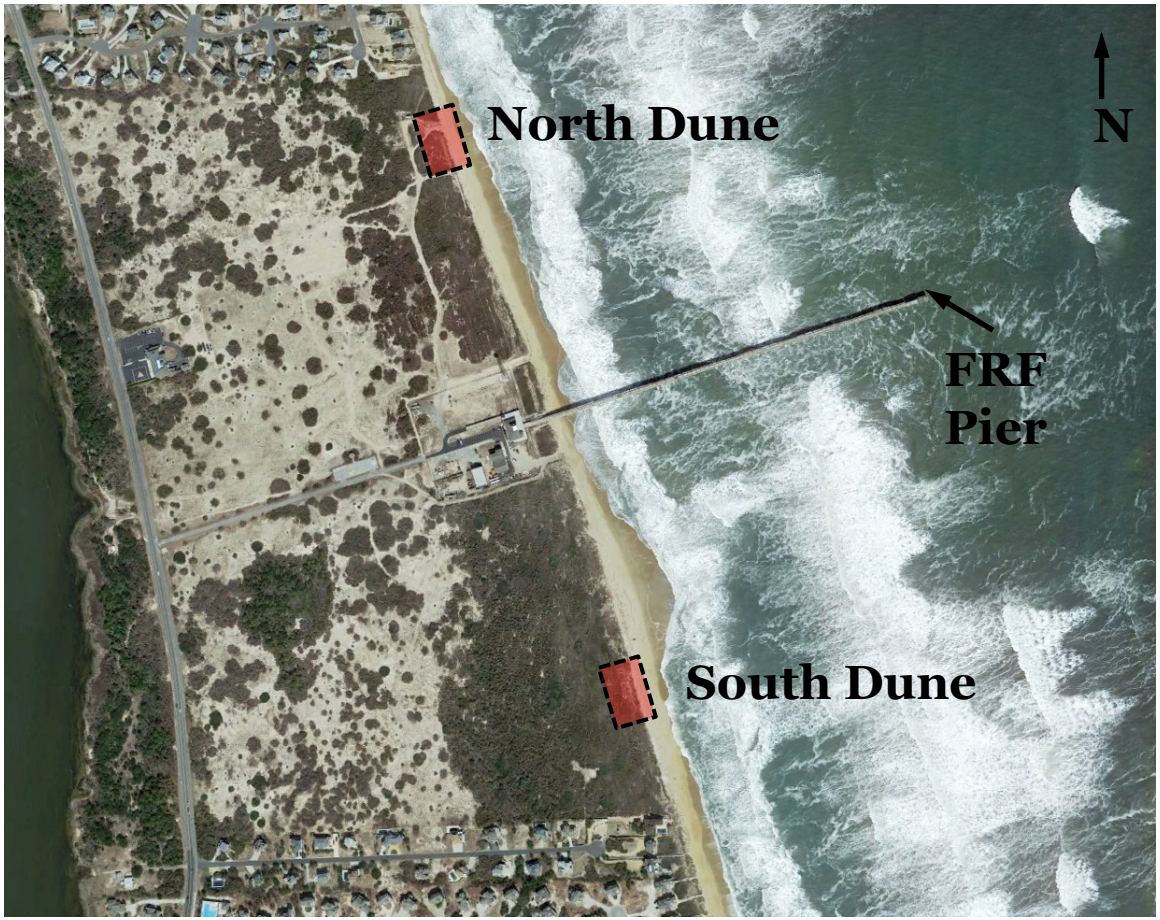
Dune Retreat Rates



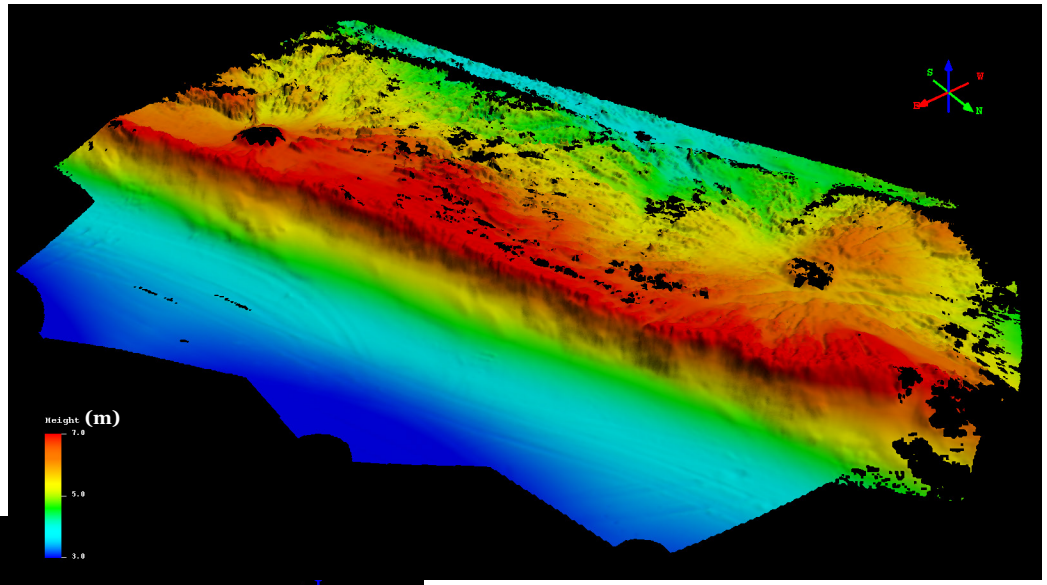
- Recovering & man-made dunes eroded more rapidly than the scarped dune
  - Both recovering & man-made dunes also had lower dune toe elevations at the start of the storm
- Recovering and man-made dunes experienced an initial drop in elevation of the dune toe whereas the dune toe of scarped dunes retreated babckward & upward at a slower rate
- **Hypothesis:** unconsolidated sediment present in both the incipient recovering foredune and the mad-made dunes combined with lower D_{low} elevations yields higher erosion rates
  - Different erosion process? More swash-like than avalanching?

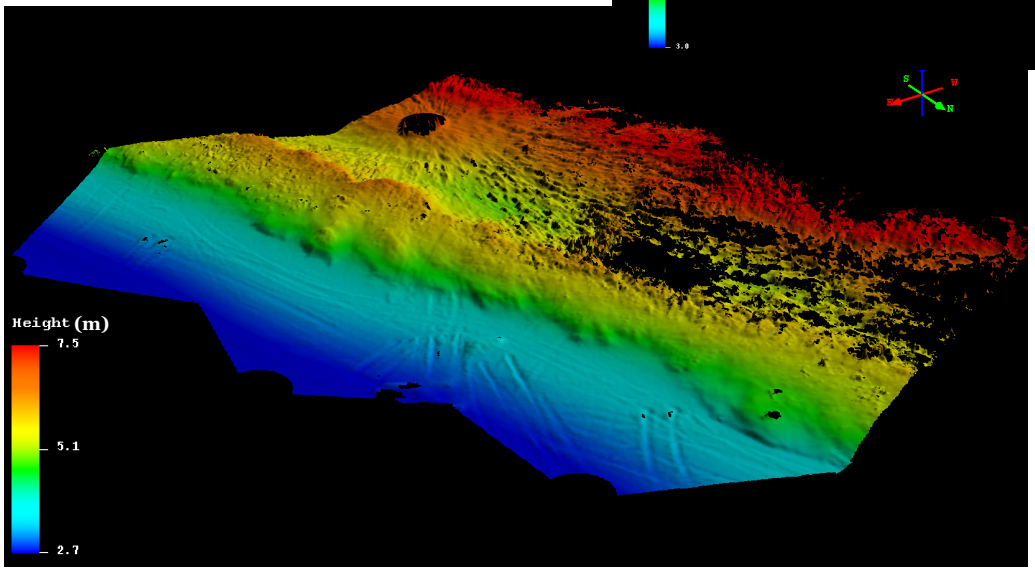
Monthly evolution of an eroding & prograding dune system



FRF North & South Dune Systems

North Dune: High (7.5m) and steeply scarped, little to no vegetation on face but thick at dune crest





South Dune: Lower (6.5m) and hummocky, vegetation present through entire dune system

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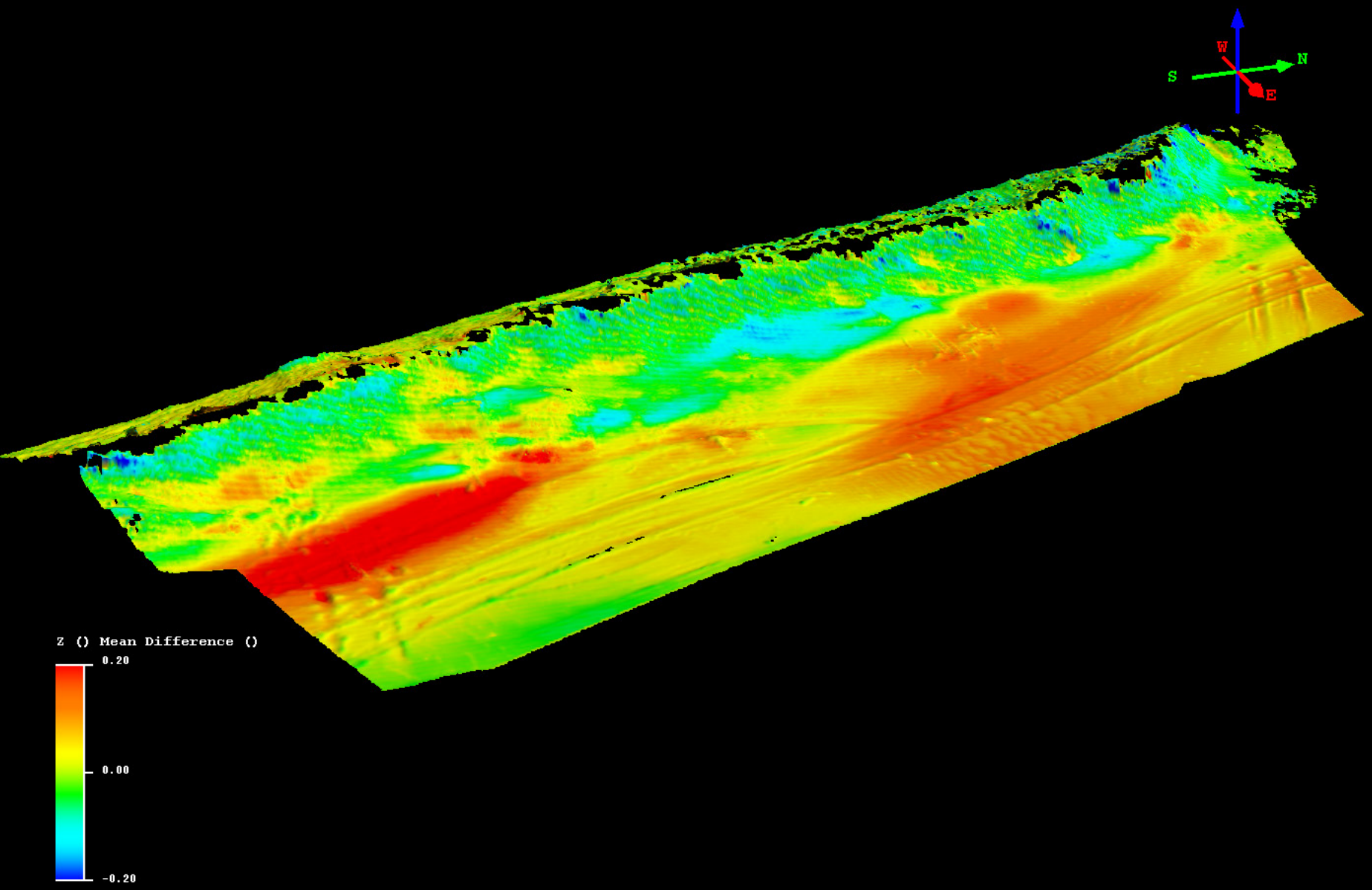
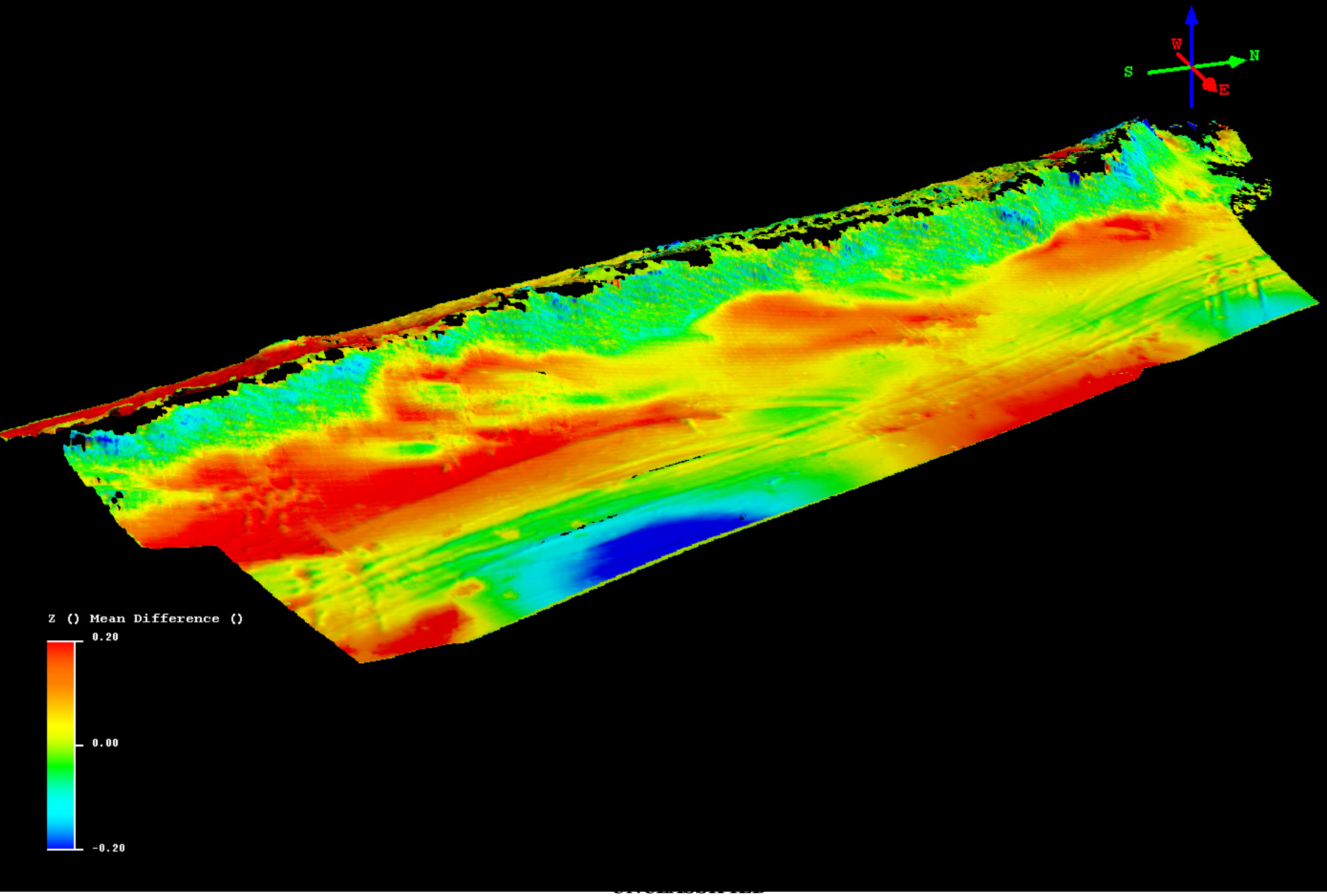
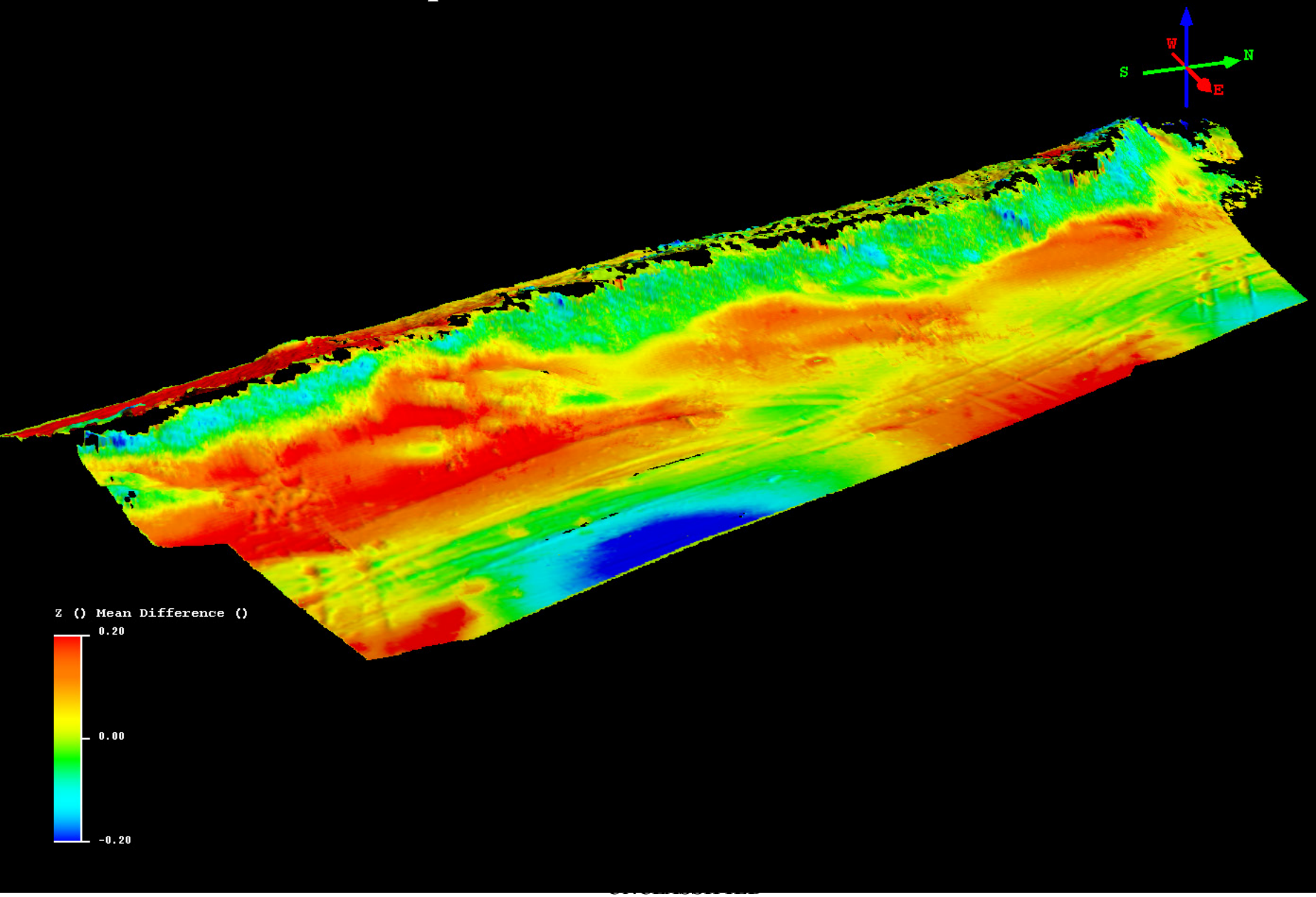
North Dune Site – Feb 6 Elevation Difference



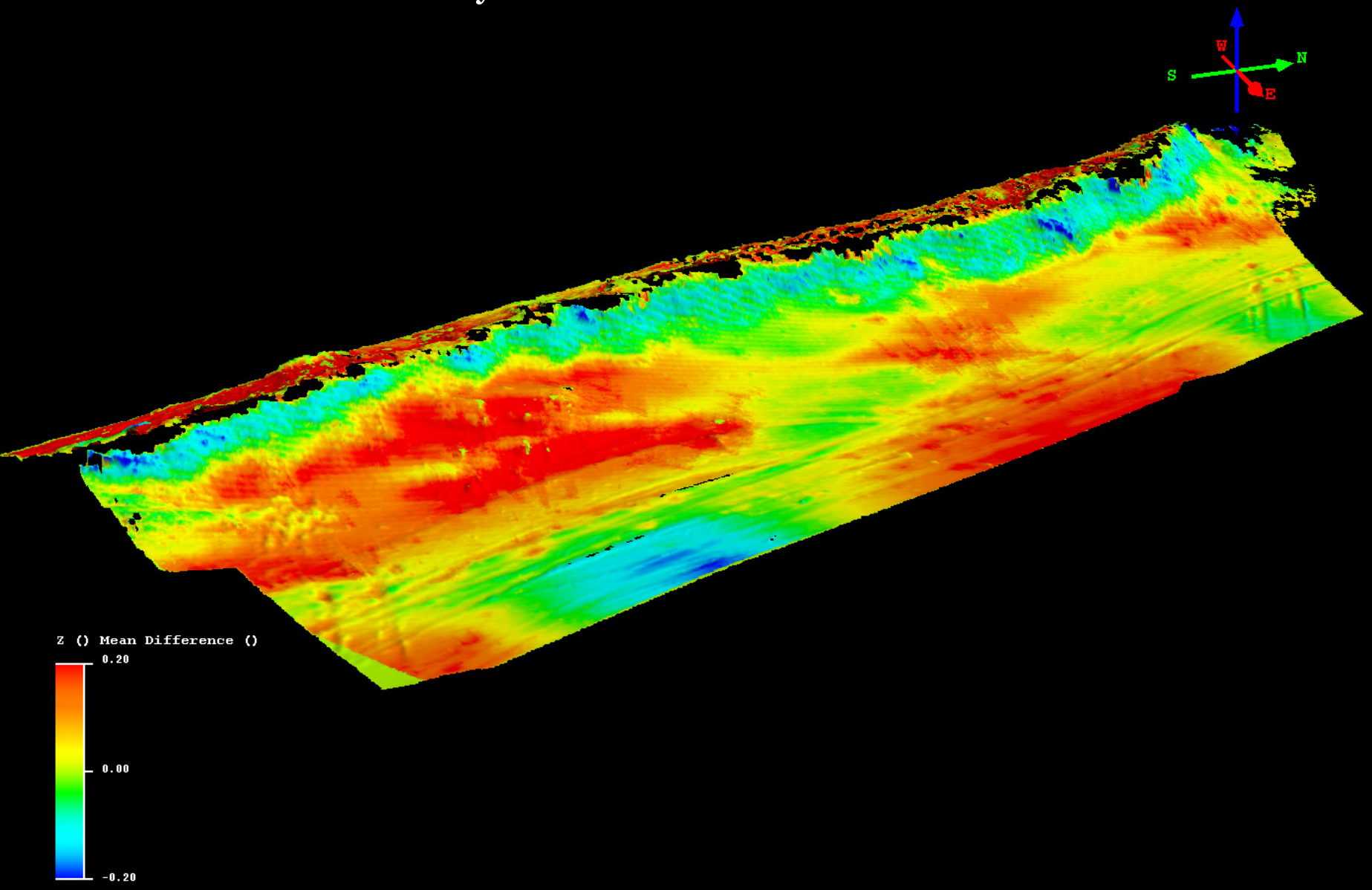
North Dune Site – Mar 25 Elevation Difference



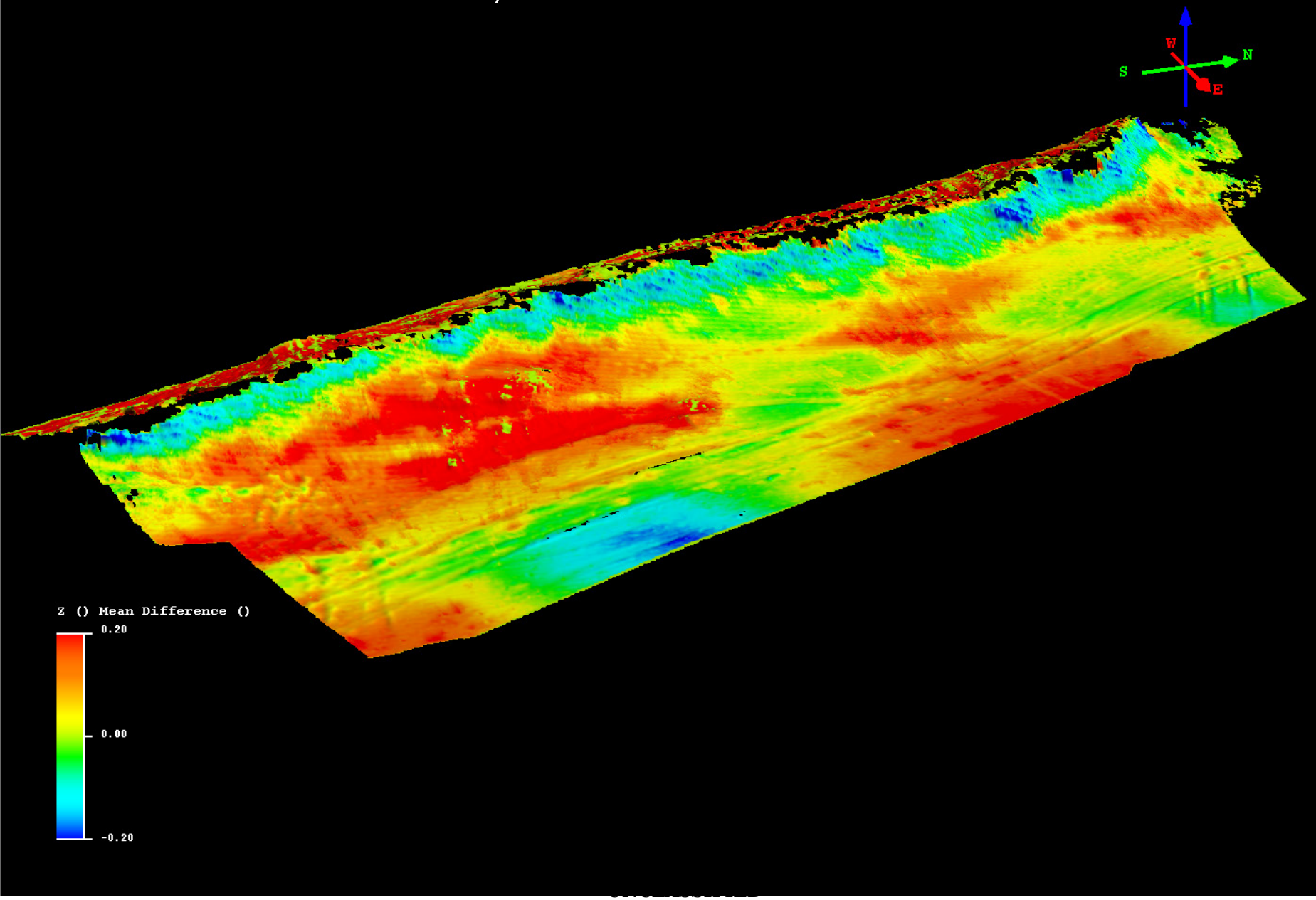
North Dune Site – Apr 10 Elevation Difference



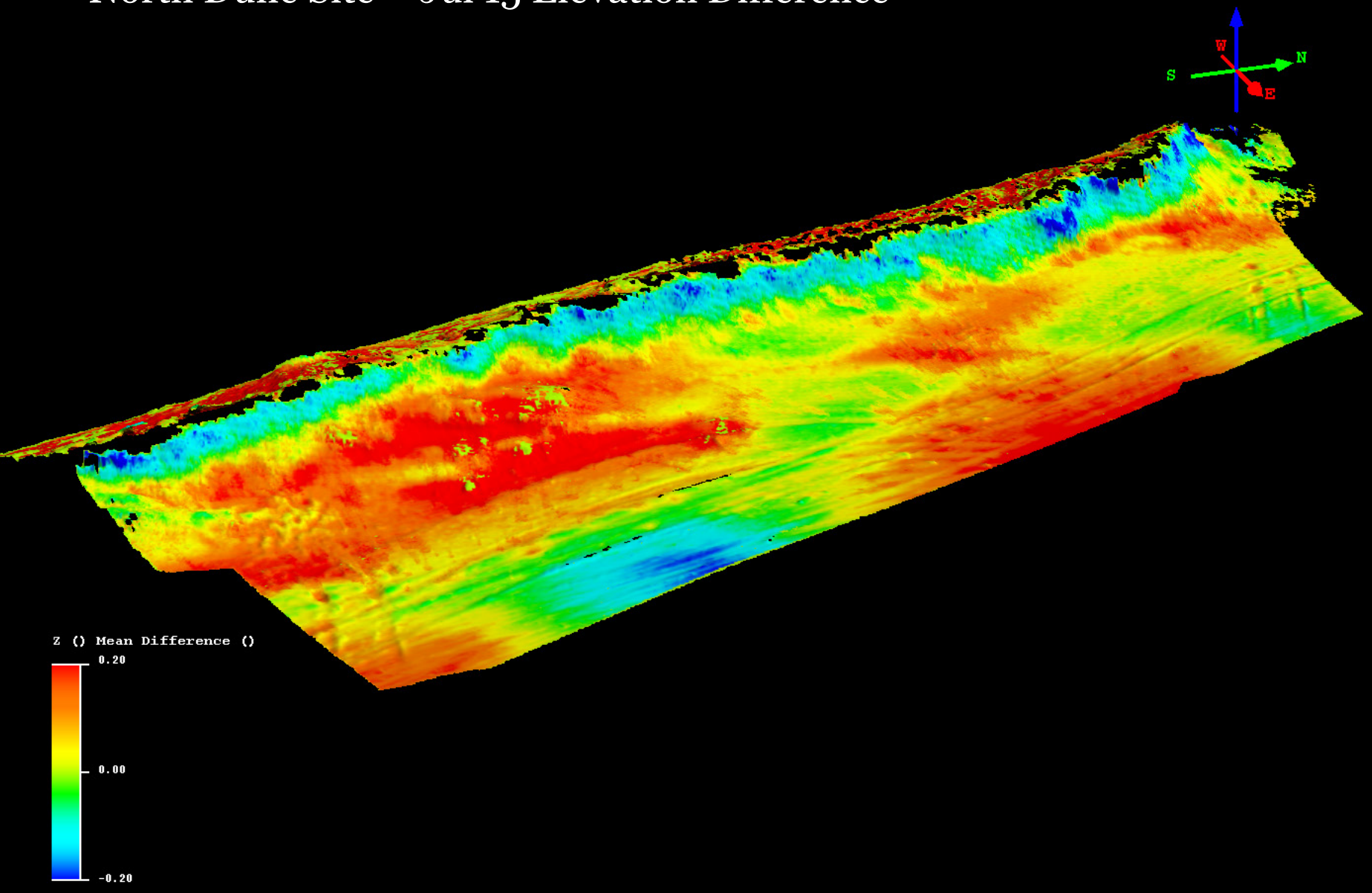
North Dune Site – May 20 Elevation Difference



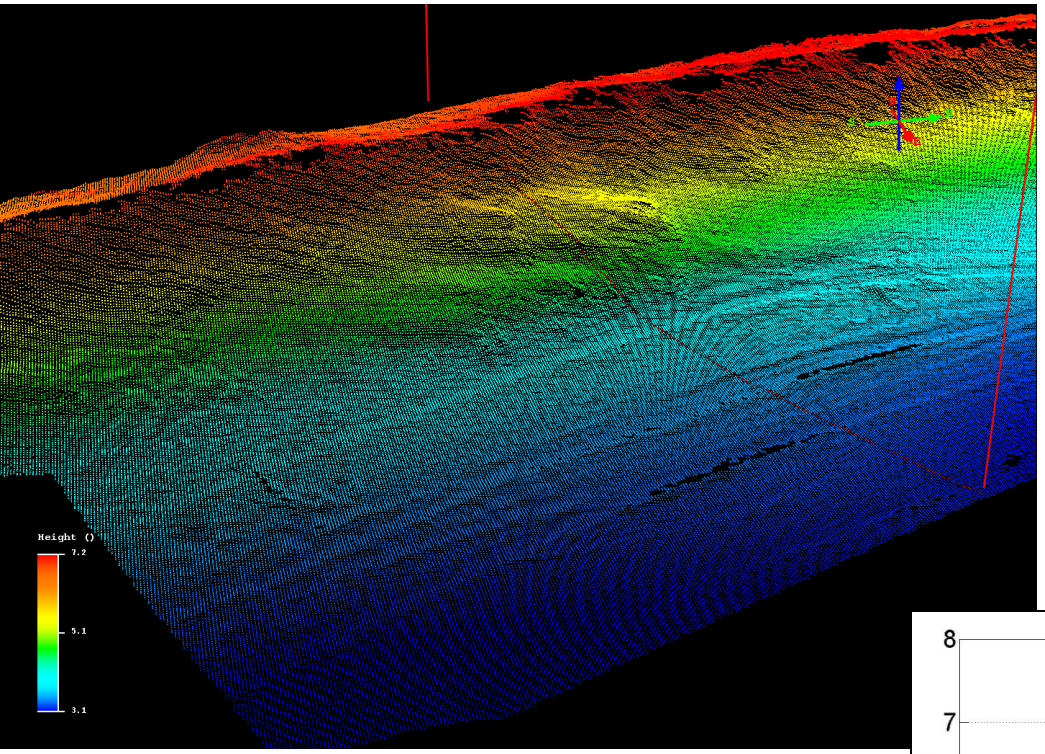
North Dune Site – Jun 17 Elevation Difference



North Dune Site – Jul 15 Elevation Difference

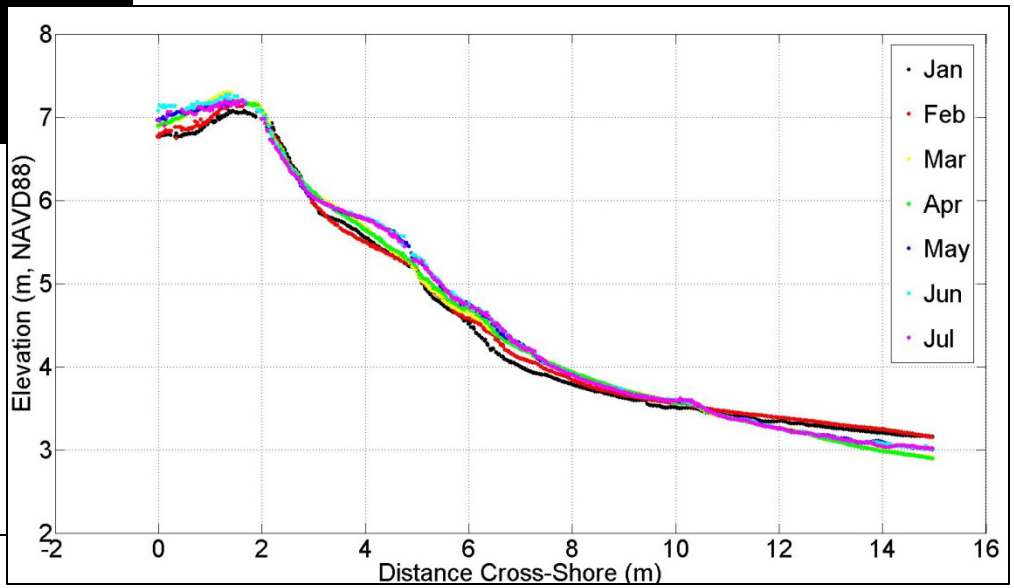


Point Cloud Analysis

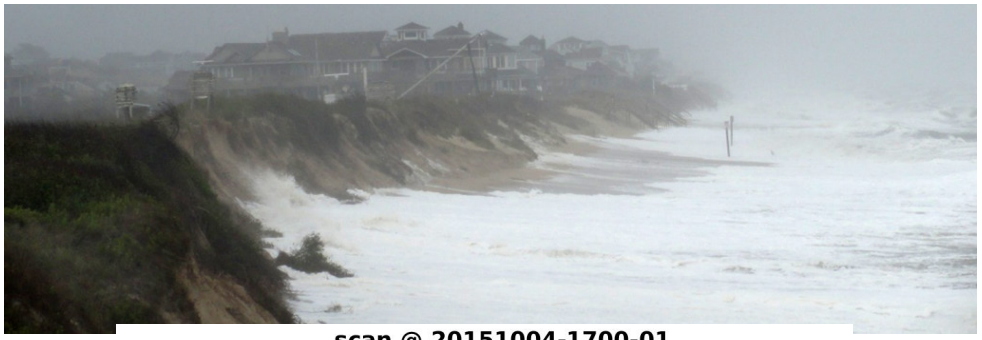


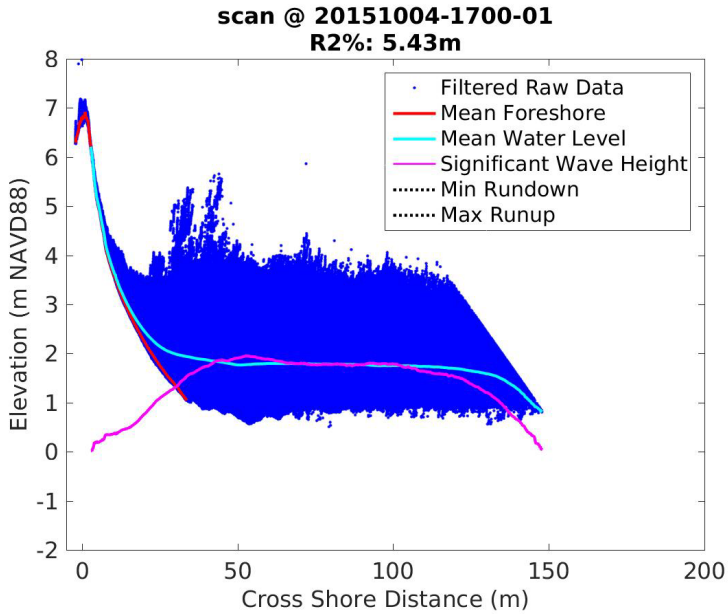
Profile transect drawn through point cloud data at 5 cm resolution

Over 7 month period some areas experienced ~40cm accretion on incipient dune

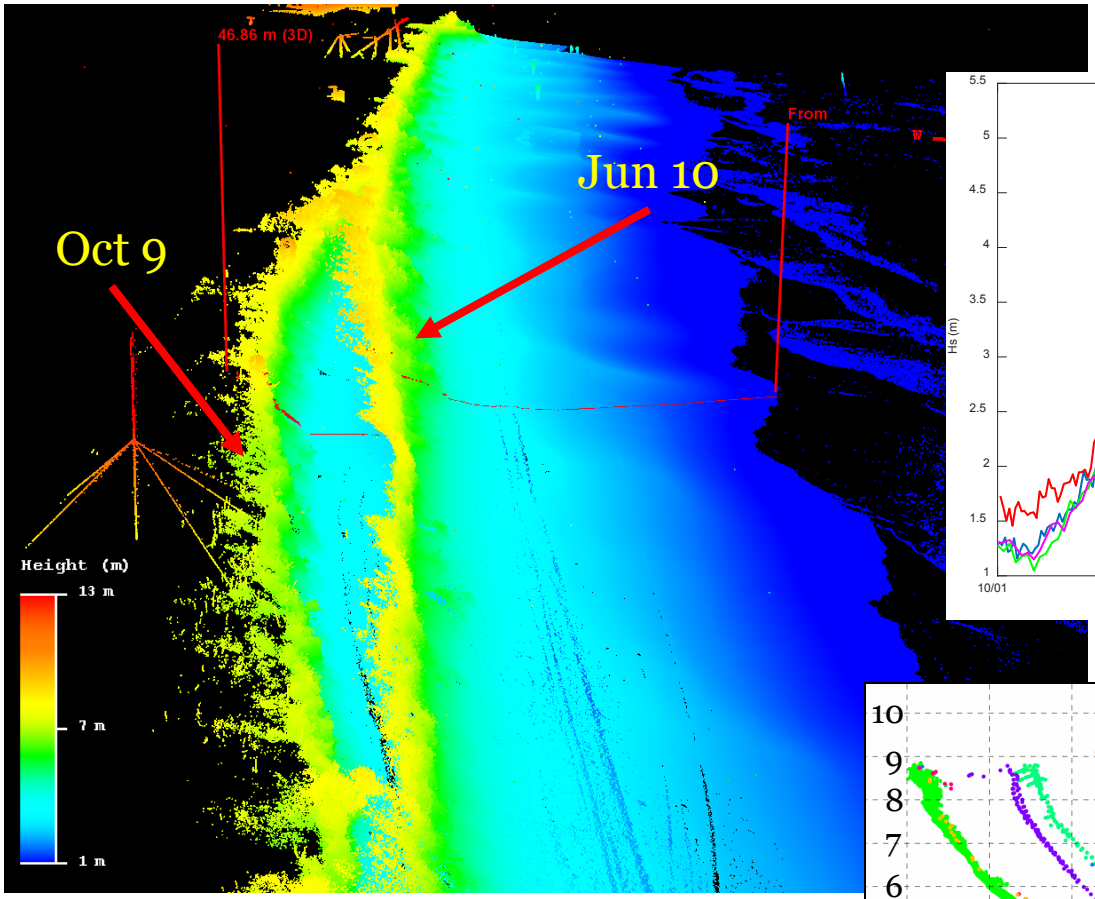


Stationary Dune Lidar

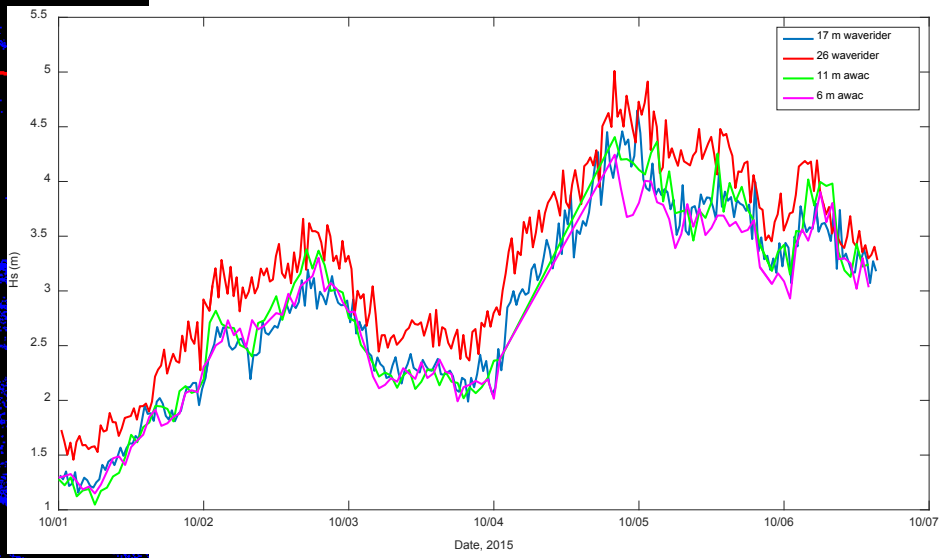




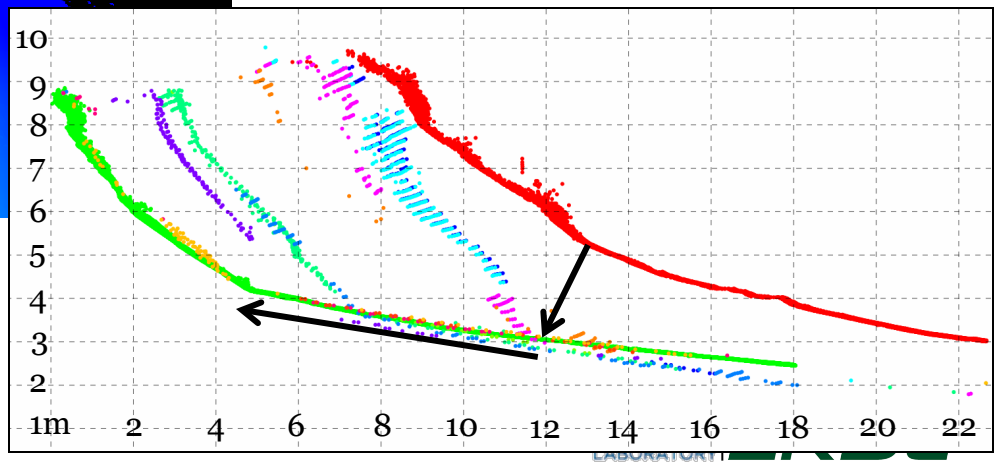
“Joaq-easter” at the FRF



Significant Wave Height (FRF gauges)



Profile Evolution



- Jun 10 – CLARIS
- Oct 9– CLARIS
- Oct 1 - 0000
- Oct 1 - 1200
- Oct 2 -0000
- Oct 2 - 1200
- Oct 3 - 0000
- Oct 3 - 1200
- Oct 4 - 0000
- Oct 4 - 1200
- Oct 5 - 0000
- Oct 5 - 1200

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