

1. Introduction

- Short-term storm response/recovery cycle understood
- Decadal variability driven by variable storminess studied
- Storm controls on coastal morphology over seasonal-interannual timescales not well documented
- How do storms influence the seasonal-interannual morphologic evolution of NASA-KSC?

2. Methods

2.1 Study Site, data

- 65 ~monthly ATV-based RTK GPS surveys between dune toe and water line (2009-2014) at NASA-KSC

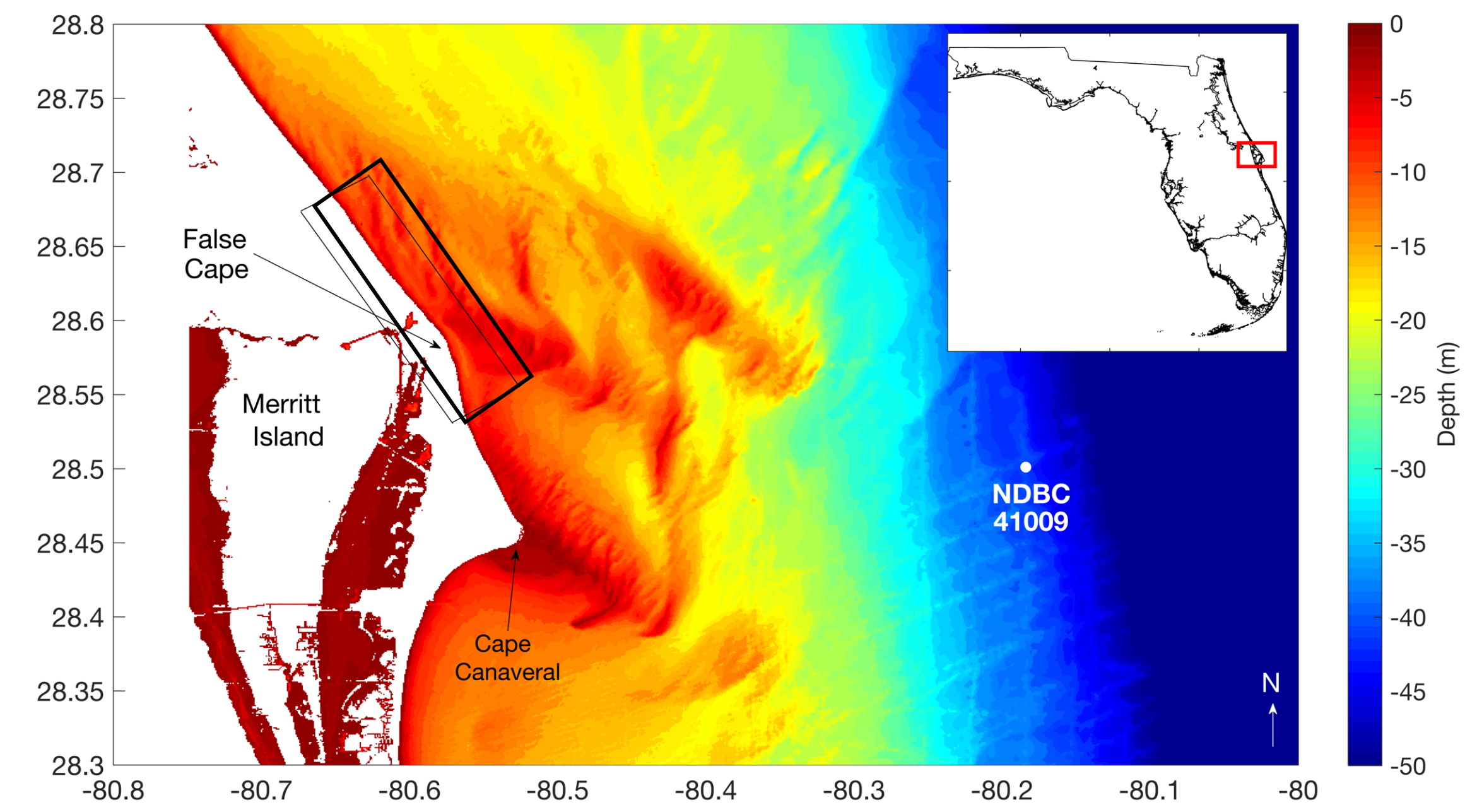


Fig. 1. Study site on east coast of Florida

2.2 Morphologic variability analyses

- Data from each survey interpolated onto grid which is oriented everywhere with the local cross/alongshore

❖ We have 65 DEMs of this location, one for each survey. Each grid point, then, contains an elevation time-series

- Morphologic change rates are found by taking linear regression elevation change rates at each grid point = Linear Regression of DEMs (LRoD)
- EOF analysis of elevation over entire beach surface through time completed = Surface EOF (SEOF)

2.3 Storm identification and analysis

- Peaks-Over-Threshold method used to ID coastal storms
- Integrated Wave Energy Density of each storm calculated

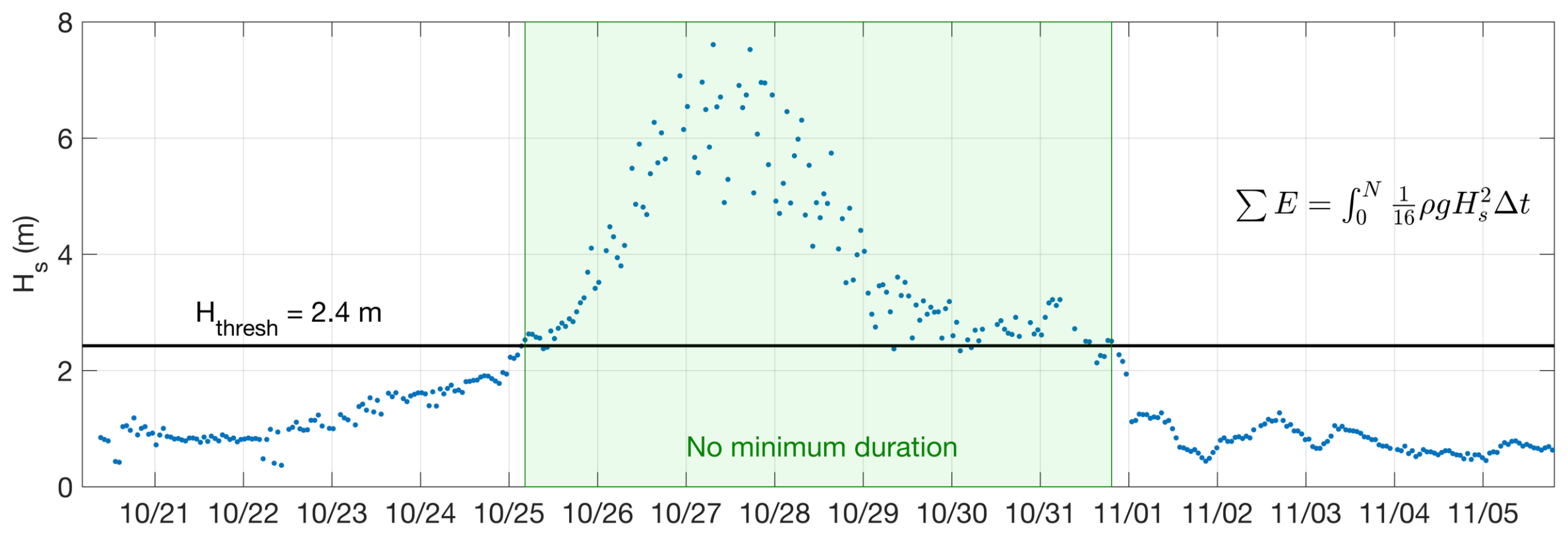


Fig. 2. Definition plot for the POT technique. A storm is identified from a record of H_s as a series of measurements (no minimum duration) exceeding a threshold $H_s(H_{thresh})$.

3. Results

3.1 Storm variability

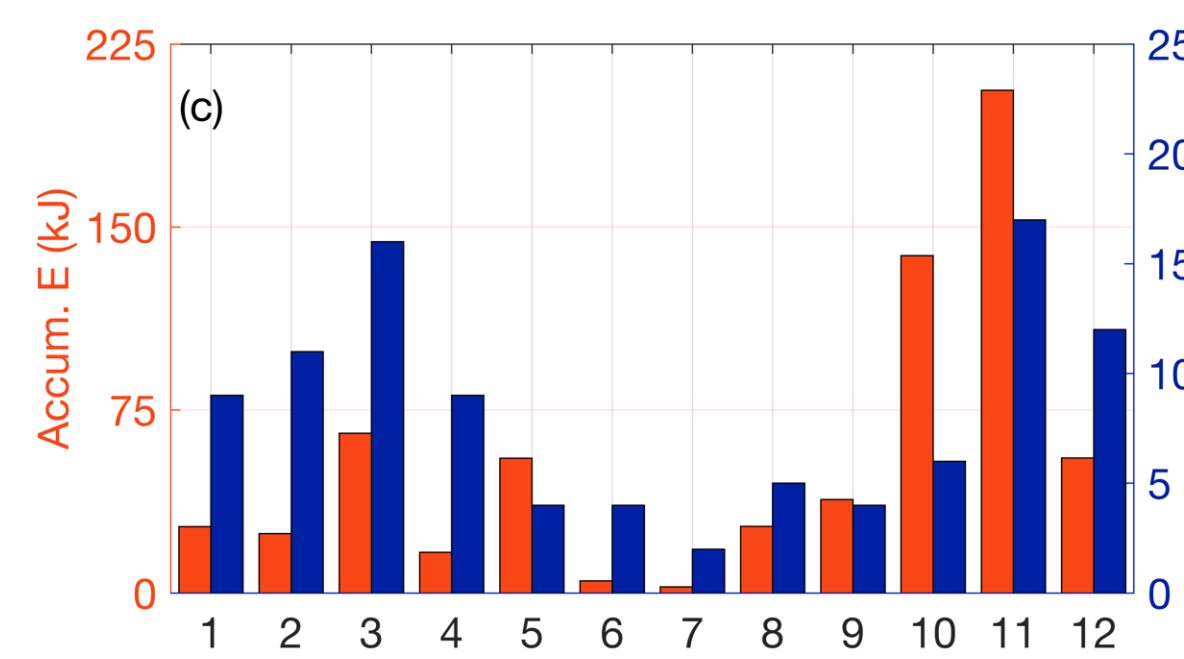
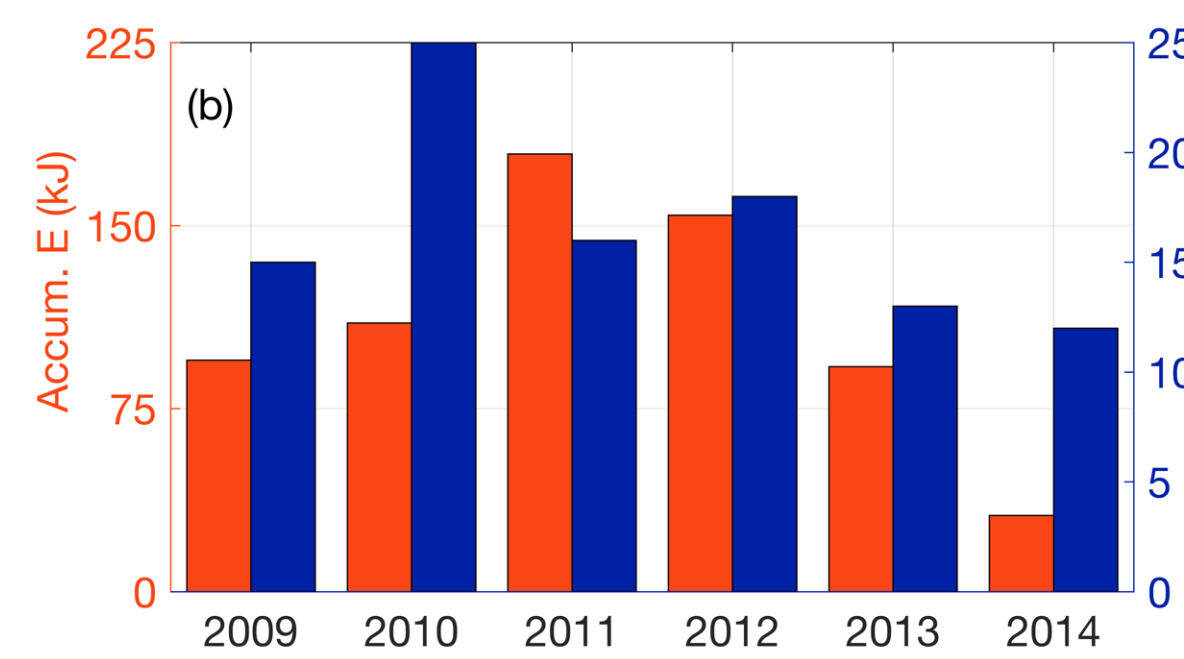
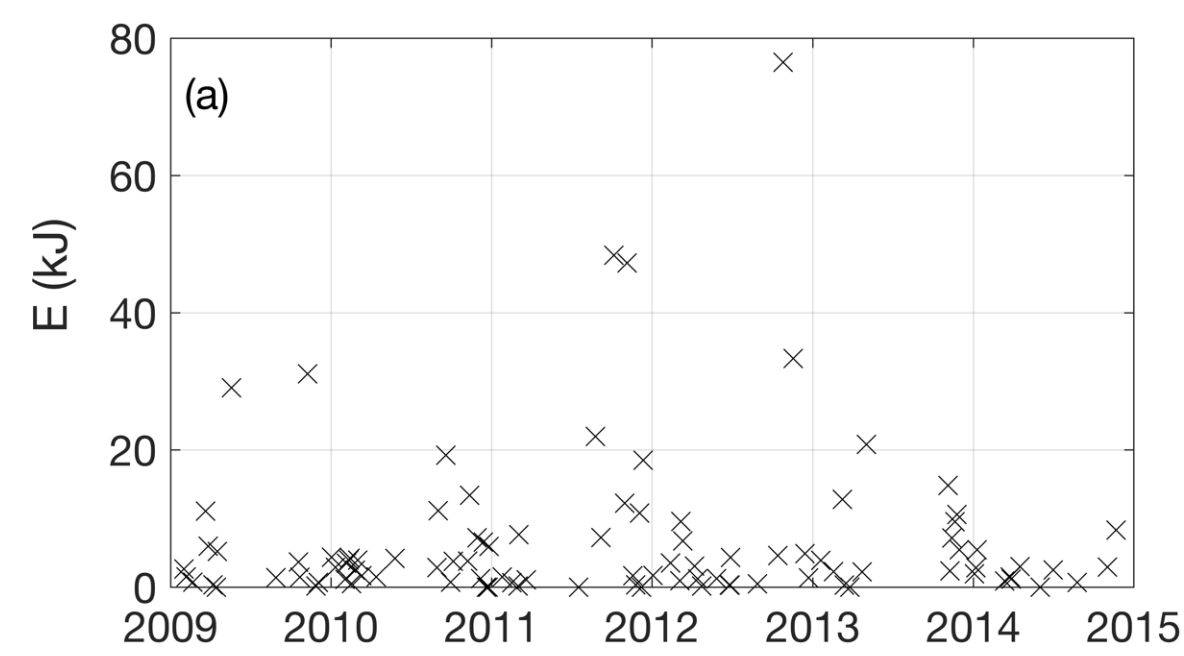


Fig. 3. Summary of identified storms. (a) Integrated wave energy density of each event. (b,c) Breakdown of storms by year (b) and month (c)

- Largest storm in October 2012 represents Hurricane Sandy (Fig. 3a)
- 4 largest storms in record hit as two clusters of two events (Fig. 3a)
- Most accumulated energy in 2011/2012, despite fewer storms than 2010 (Fig. 3b)
- October-January were months which saw the most storm energy (Fig. 3c)
- Nearly zero storm energy in Jun/Jul (Fig. 3c), illustrating seasonal cycle in storm activity

3.2 Morphologic variability

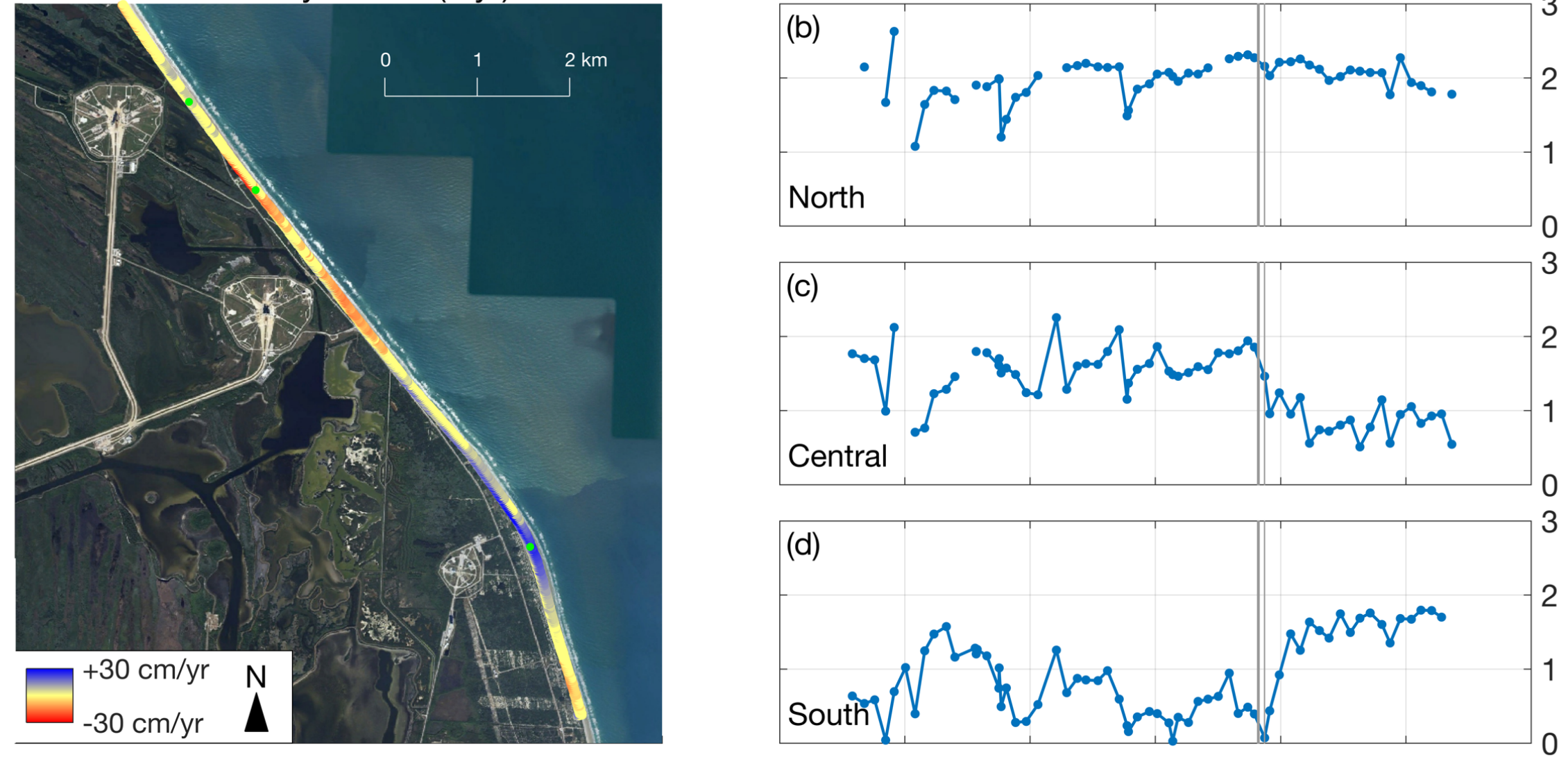


Fig. 4. (Left) LRoD calculated over full study period, with elevation time-series at three example grid points (b-d). Grey bars indicate timing of Sandy and a following winter storm

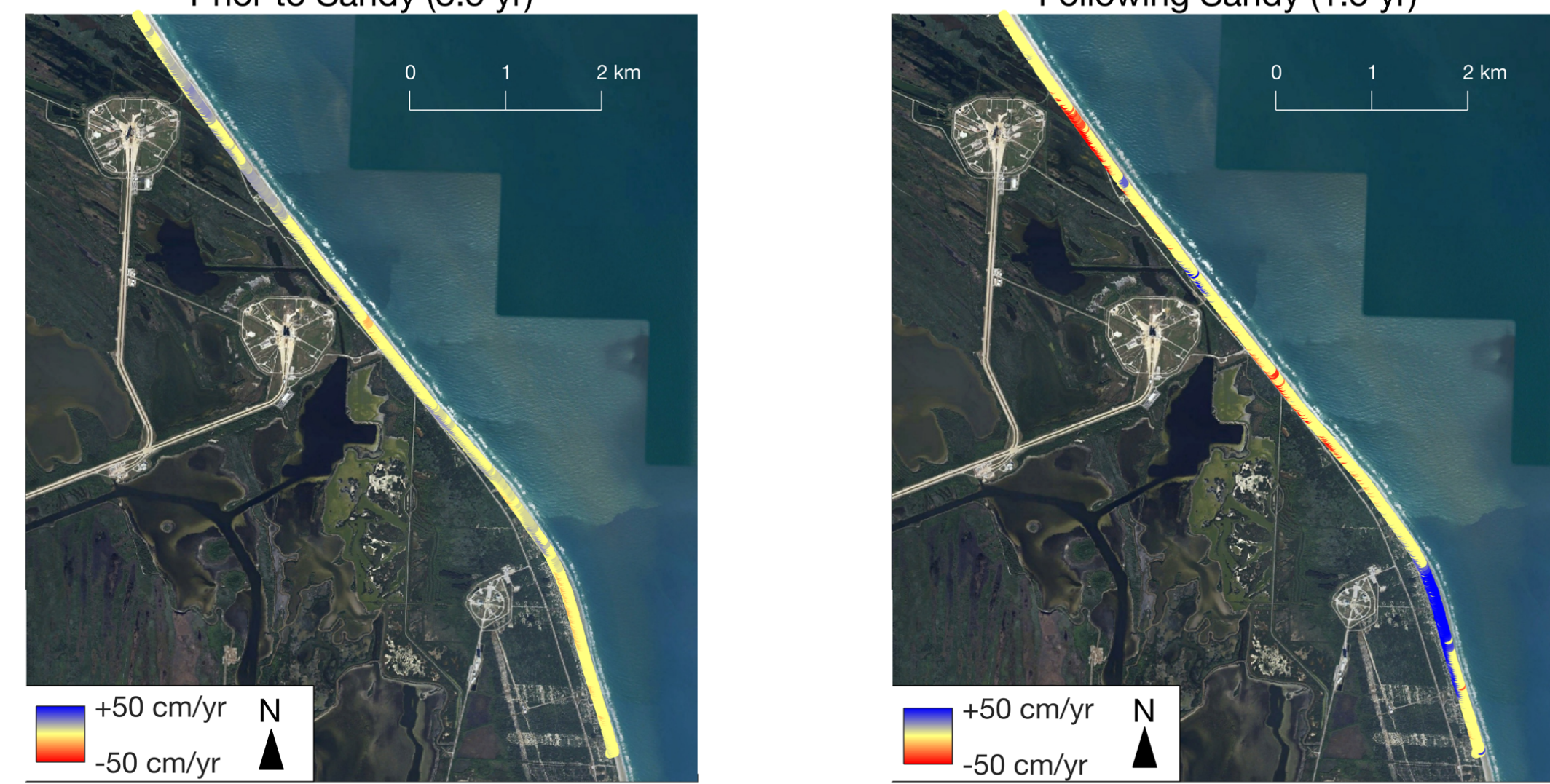


Fig. 5. LRoDs calculated prior to and following Sandy

3.3 SEOF analysis

- Overall: False Cape accretional, isolated erosion, most of site stable (Fig. 4, left)
- Non-stationary variability at central and southern grid points; shift in behavior immediately following Sandy and a following storm (Fig. 4c,d). This results in 4-month accretion at southern point, erosion at central, followed by stability for remaining 1.5 yr of measurements
- After the storms: southern False Cape highly accretional, some northern reach erosional. These trends not apparent before (Fig. 5)

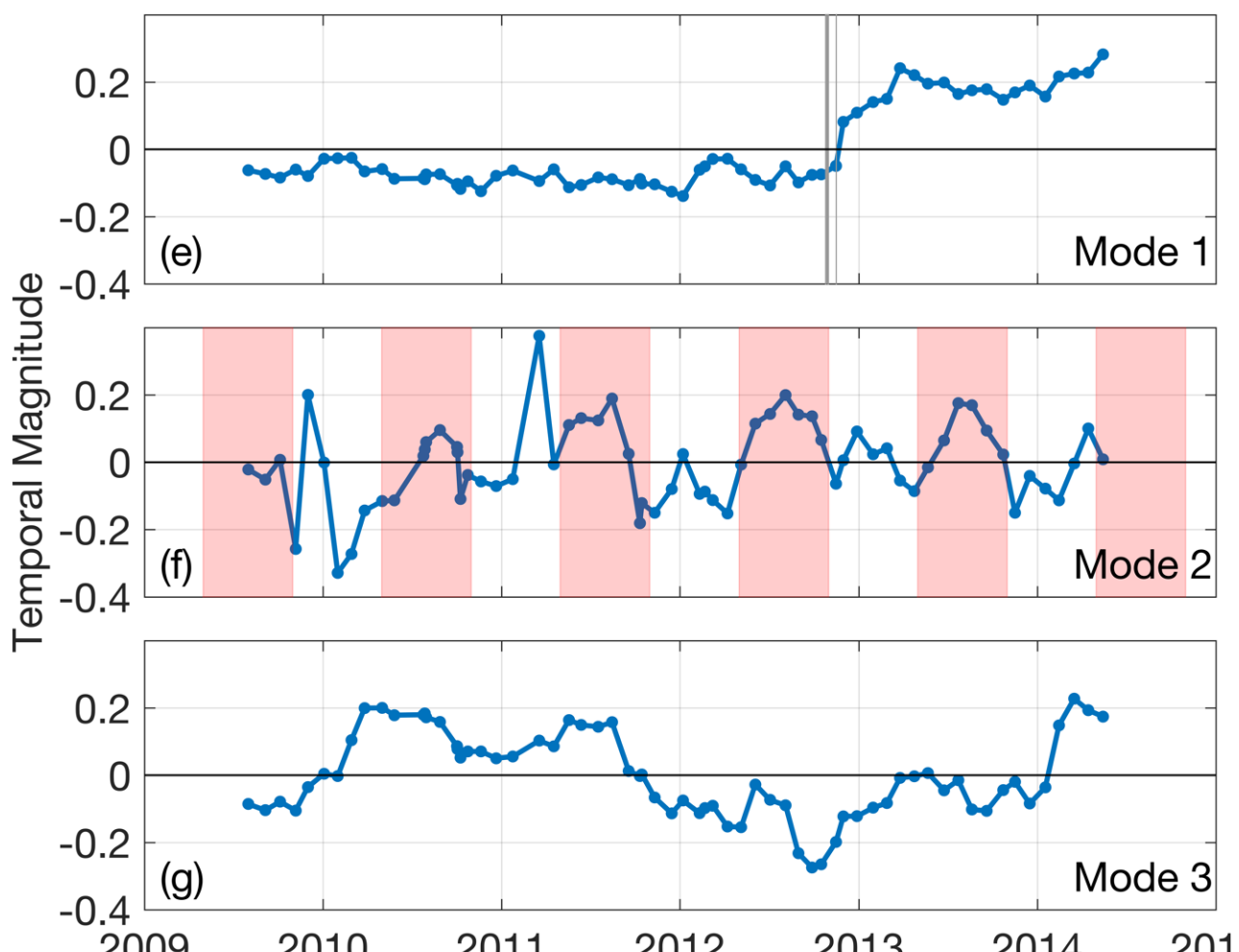
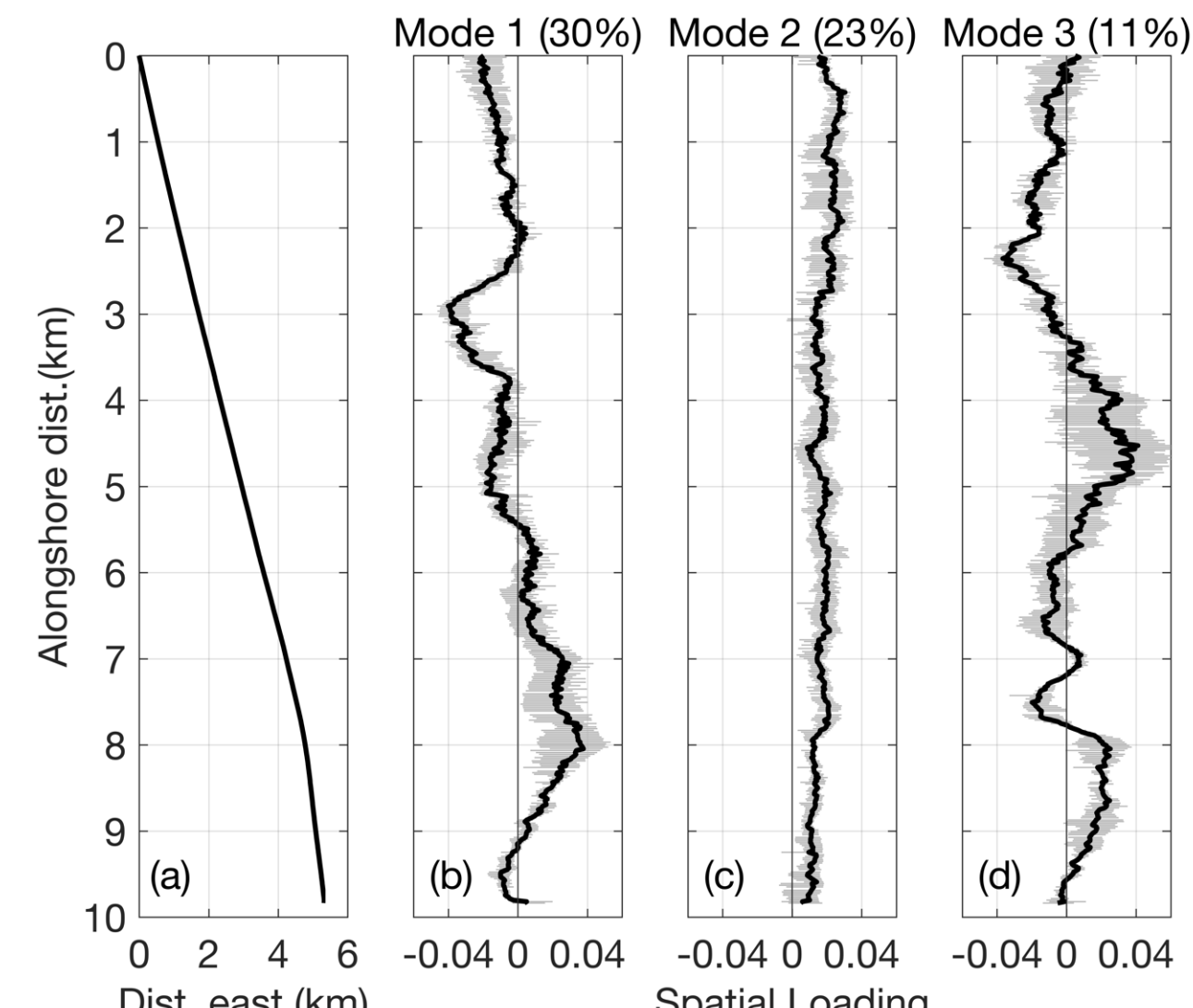


Fig. 6. Results of the SEOF analysis. (a) Planview representation of the study site. (b-d) Plots of the cross-shore averaged spatial loading for Modes 1-3, where grey bars indicate cross-shore variability. (e-f) Time-series of temporal magnitudes for Modes 1-3. Gray bars in (e) represent the timing of Hurricane Sandy and a following winter storm. Red bars in (f) represent May 1 - October 31 of each year.

4. Discussion (Mode 1)

- Morphologic state change (Mode 1) occurs immediately following storms = events caused the change
- Explanation:

Storms caused southern portion of False Cape to accrete/advance + Waves are typically from the northeast = Protrusion smeared itself along southern reach over next 4 months, return to equilibrium

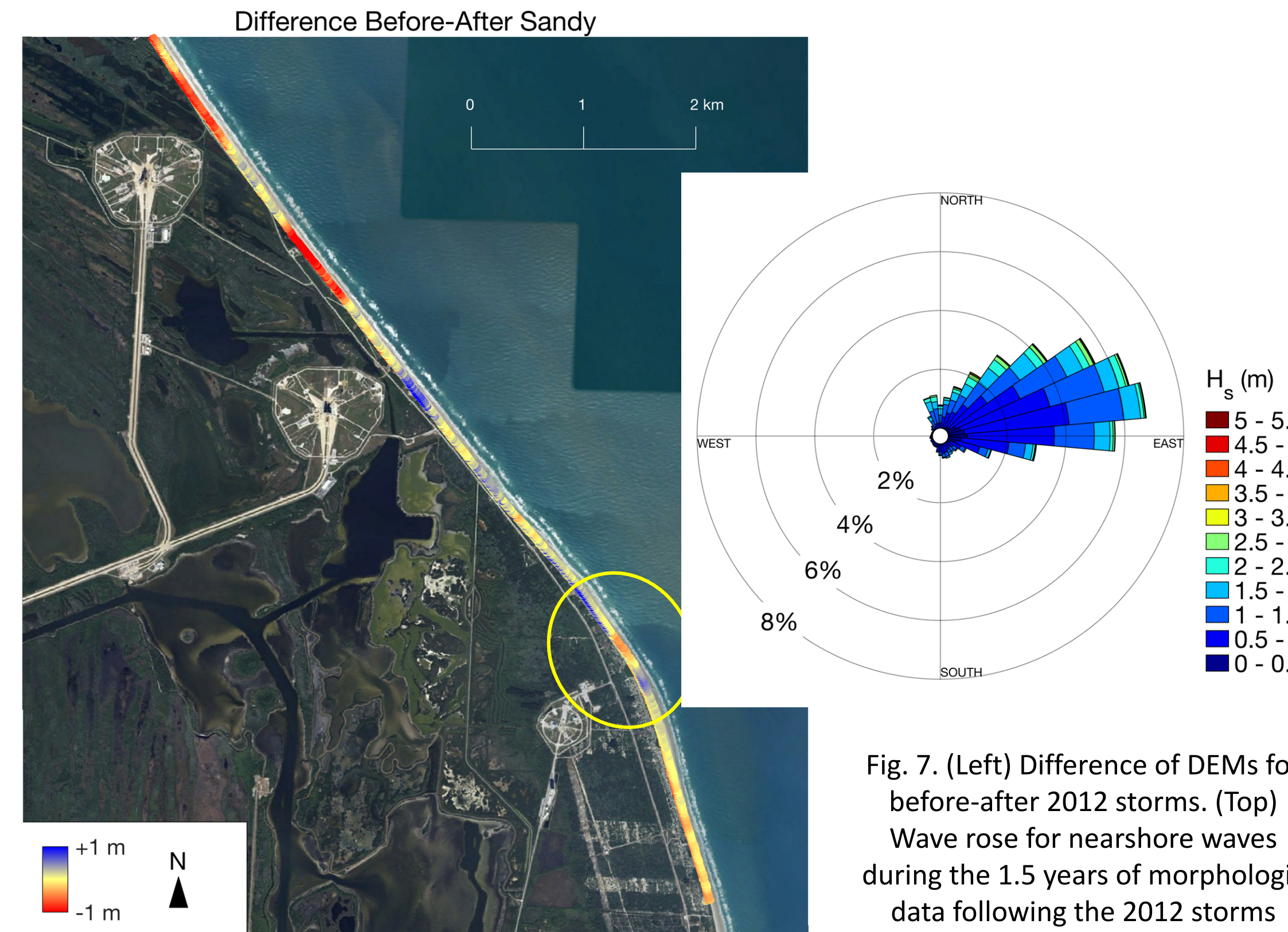


Fig. 7. (Left) Difference of DEMs for before-after 2012 storms. (Top) Wave rose for nearshore waves during the 1.5 years of morphologic data following the 2012 storms

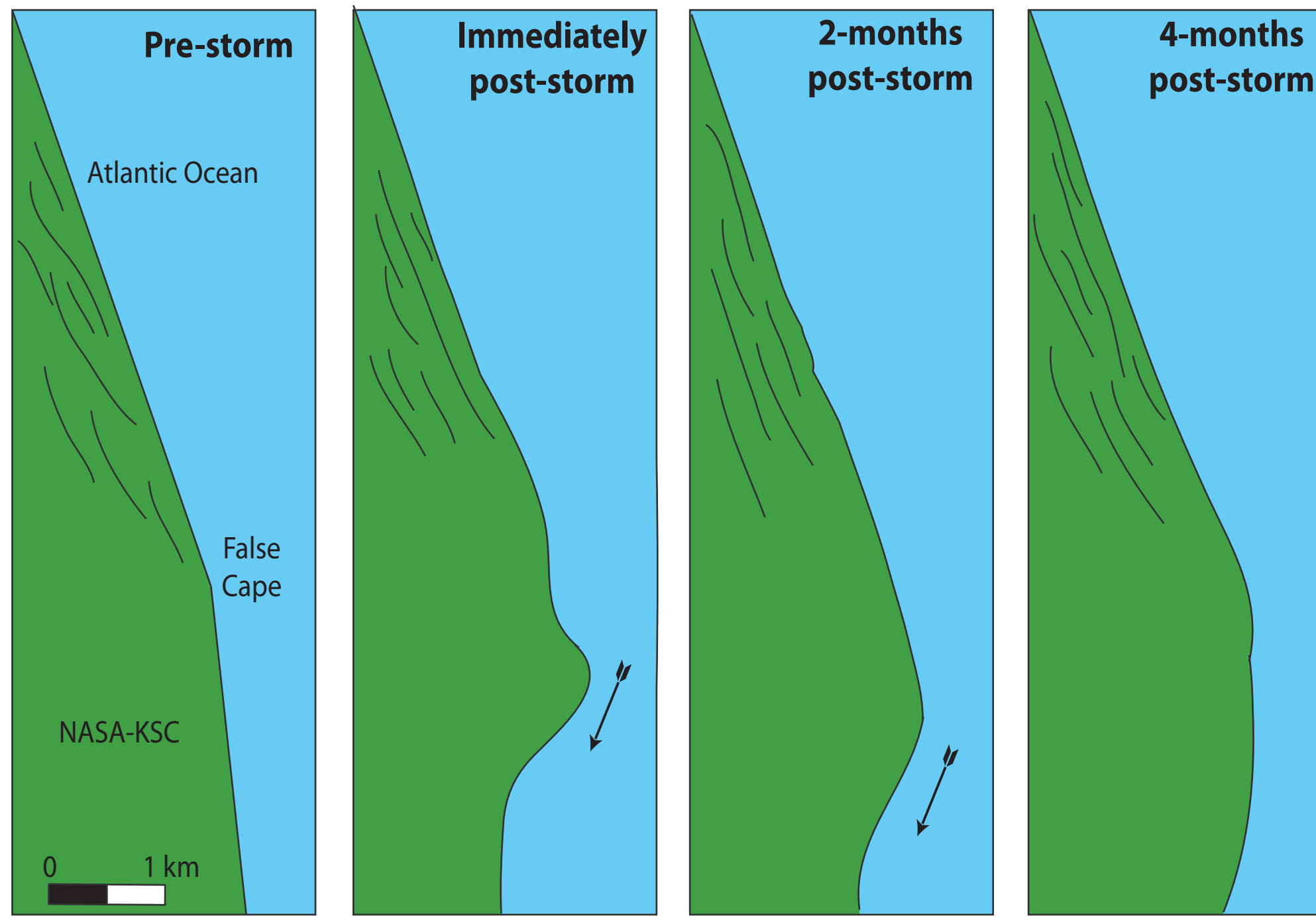


Fig. 8. Hypothesized multi-month evolution of the site following 2012 storms (exaggerated)

- Response to storm dictated recovery through morphologic equilibrium shifts driven by storm conditions
- We know that recovery influences response to the next storm by setting the baseline upon which it acts
- Therefore, response from one storm can influence response to the next storm, illustrating a coupling between response and recovery which was the dominant control on the interannual evolution of this site

4. Discussion (Modes 2+3)

- Mode 2 indicative of seasonal morphologic changes due to seasonal water level variations
- Temporal variability matches storm variability

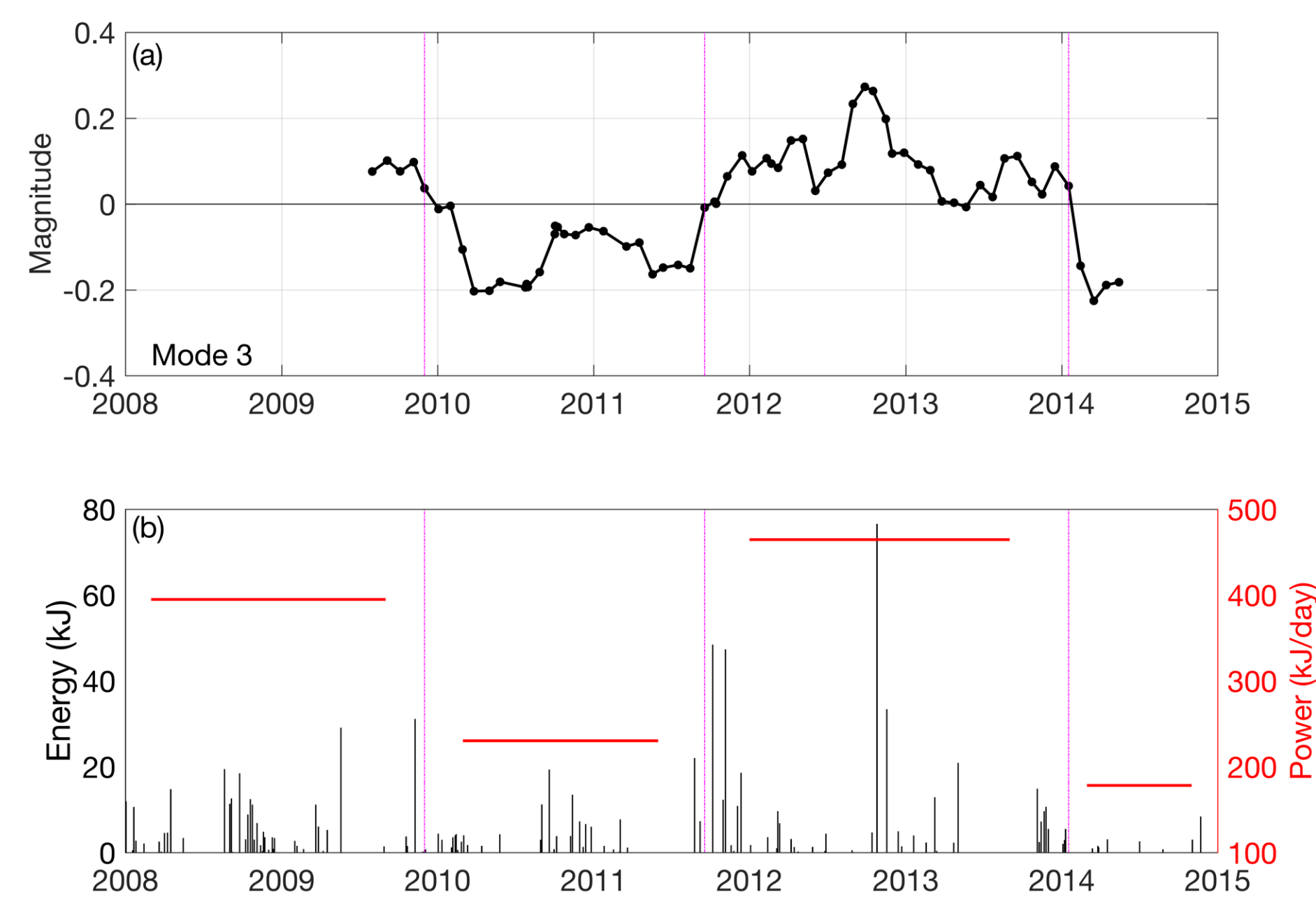


Fig. 9. Correlation of Mode 3 with periods of storminess. (a) Time-series of Mode 3 temporal magnitudes. (b) The integrated wave energy density of each storm (black bars) and storm power over time periods between magenta vertical lines

- Mode 3 positive during periods of intense storminess, negative during low storminess
- This suggests an underlying morphologic response to interannual storminess cycles
- Could correspond to variations in sediment storage location and accessibility from variable storminess

5. Summary: key points

- We use a dataset containing monthly topographic observations for 5-years to document the influence of storms on the seasonal-interannual evolution of a 10-km stretch of beach in Florida
- We find that Sandy's impact (2012) caused a morphologic change of state, dictating an evolution following the event which was unlike that of before
- We show that storm response dictated recovery, and it is known that recovery influences response to the next storm, so these results highlight a complex coupling between response and recovery which was the dominant control on interannual evolution here
- Morphology at this site also seems to respond to seasonal variations in storm activity and interannual storminess cycles