Geomorphic signatures of coastal change from multiple satellite-derived change indicators

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February 26, 2024
Geomorphic signatures of coastal change from multiple satellite-derived change indicators

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PhD: “The Construction of a Real-time Coastal Erosion Monitoring and Forecasting System”

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Why is coastal change important to measure?

1.3% of global pop. currently impacted by 100-year flood events

Increased exposure + no adaptation = 10% of global GDP in damage costs by 2100

BBC: “Storm Ciarán to bring up to 80mph winds in wake of Storm Babet clean-up”
Why is coastal change important to measure?

- Storms/Wind
- Vegetation
- Human Influence
- Sediment Transport
- Waves
- Sea Level Rise

Increased exposure + no adaptation = 10% of global GDP in damage costs by 2100 (Hinkel et al., 2014)

1.3% of global population currently impacted by 100-year flood events (Muis et al., 2016)
Coastal change indicators: only part of the story?

- Instantaneous shorelines (CoastSat, SHOREX, CASSIE)
- Yearly composite shorelines (ShorelineMonitor, HighTide-SDS)
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10 days later: topo or hydro change?
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10 days later: topo or hydro change?
Watching the grass grow: Framework of VedgeSat

User Requirements & Satellite Data Collation

Landsat 5/7/8/9 (15m), Sentinel-2 (10m), PlanetScope (3m)

Based on CoastSat (Vos et al., 2019)

More details on the poster!
Board EP43C-2429, Poster Hall A-C, Thurs 14th 2:10PM–6:30PM
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Clouds

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**Neural Network Classification**

Multispectral band indices (NDVI, NDWI, RB-NDVI, NGRI, SAVI)

Pre-trained neural network classifies ‘veg’ and ‘non-veg’

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Image Pre-processing

Neural Network Classification

Sub-pixel Contouring

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Pre-trained neural network classifies 'veg' and 'non-veg'

Weighted Peaks thresholding

Marching Squares extracts sub-pixel veg edge contour

Landsat 5/7/8/9 (15m), Sentinel-2 (10m), PlanetScope (3m)

Clouds

Density

NDVI

Non-veg

Veg

Weighted Peaks thresholding

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Transition Zone: 1\textsuperscript{st} and 10\textsuperscript{th} Veg Percentiles

Wider transition zone = diffuse vegetation signal = greater physical resilience?

User Requirements & Satellite Data Collation → Image Pre-processing → Neural Network Classification → Sub-pixel Contouring

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Satellite-derived change indicators

Validation site: Muir et al., 2023 (in review)
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Vegetation change rate (m/yr)
- <= -2
- 0
- >= 2

~1400 total transects
Satellite-derived change indicators

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Cross-shore timeseries as a measure of beach health
Cross-shore timeseries as a measure of beach health

Transect 1325

- Sat. VegEdge
- 2.29 m/yr

Transect 271

- Sat. VegEdge
- -1.68 m/yr

Date
Cross-shore timeseries as a measure of beach health

Transect 1325

Sat. VegEdge
3pt Mov. Av. VegEdge
2.29 m/yr

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TZwidth (m)
TZwidth_η (34 m)
TZwidth_η (14 m)
Trend-informed analysis

Transect 1325

Cross-shore dist (m)

- Waterline 2.09 m/yr
- VegEdge 2.63 m/yr

Overall trend (m)

Seasonal signal (m)

- Waterline Resid.
- VegEdge Resid.


Transect 271

Cross-shore dist (m)

- Waterline -20.93 m/yr
- VegEdge -1.71 m/yr

Overall trend (m)

Seasonal signal (m)

- Waterline Resid.
- VegEdge Resid.


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Trend-informed analysis

Transect 1325
- Waterline: 2.09 m/yr
- VegEdge: 2.63 m/yr

Transect 271
- Waterline: -20.93 m/yr
- VegEdge: -1.71 m/yr

Overall trend
- Transect 1325: Stable trend
- Transect 271: Variable trend

Seasonal signal
- Transect 1325: Seasonal variations
- Transect 271: Seasonal variations

Waterline Resid.
- Transect 1325: Residuals
- Transect 271: Residuals

VegEdge Resid.
- Transect 1325: Residuals
- Transect 271: Residuals
Multivariate Analysis: Fitting the cogs together
Multivariate Analysis: Fitting the cogs together

- **Δveg (m/yr)**
  - Eroding $r = 0.65$
  - Accreting $r = 0.63$

- **Δwater (m/yr)**
  - Eroding $r = 0.55$
  - Accreting $r = 0.23$

- **TZwidthη (m)**
  - Eroding $r = -0.69$
  - Accreting $r = 0.19$

- **slope_{max} (°)**
  - Eroding $r = -0.32$
  - Accreting $r = -0.02$
Future directions

• Bring in anthropogenic data
  • Intersecting observed past and modelled future vegetation with coastal assets
  • Natural System Resilience supports Community Resilience

• Bring in wave data
  • Hindcast analysis of veg vs. wave climate
  • Forecasting of vegetation response using data-driven modelling

Last week

Next week

DynamicCoast.com

Waves

Human Influence

Assets within 1km of MHWS
- Developed
- Less Developed
- Undeveloped

Future Erosion by 2050 under High SLR

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Big coastal datasets offer novel geomorphic insights

Variability of veg edge much less than instantaneous waterline across macrotidal regions → better indicator of long-term coastal change

Nuanced metrics like the transition zone width offer a measure of coastal geomorphic resilience → helps inform adaptation decisions to improve coastal community resilience

Value of monitoring both veg- and water-based edges; important for practical applications with limits on scope

Thank you!

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VedgeSat tool
(COASTGUARD Github)

References