Modeling Interannual Dune Growth and Recovery on a Developed Barrier Island

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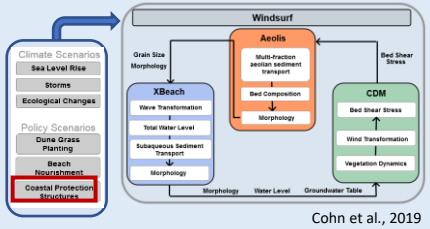
Questions

1. How do dune and beach erosion and recovery differ between developed and undeveloped dunes and beaches?
2. How accurately can hindcast simulations reproduce observed dune and beach erosion and recovery?
3. How can we combine process-based modeling and data-driven methods to forecast interannual dune and beach changes?

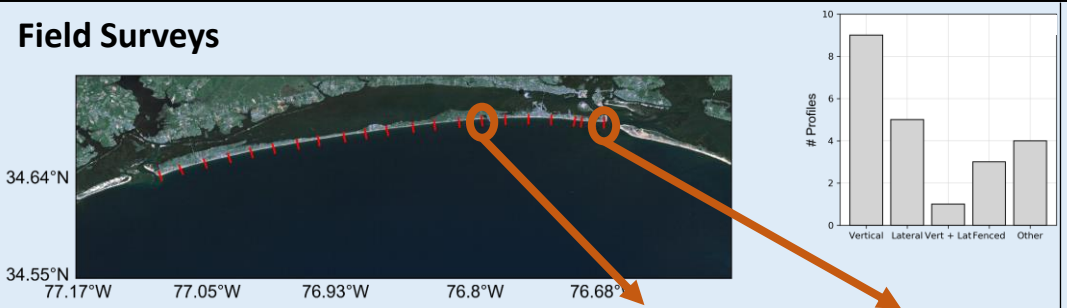
Windsurf



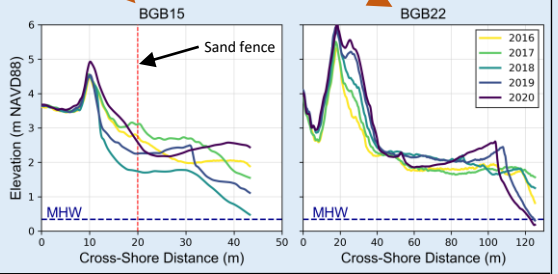
Cohn et al., 2019

- Coupled beach-dune modeling system
- Simulates change across the profile for both erosion and recovery periods
- Modified to simulate artificial dune growth from the use of sand fences on managed beaches

Field Surveys



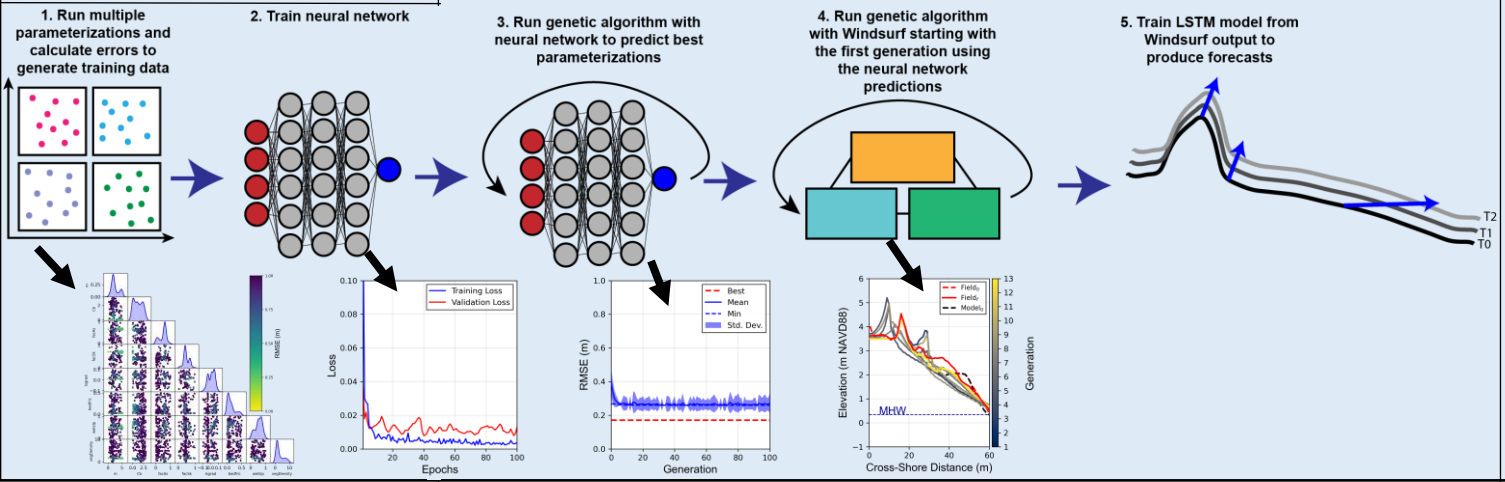
- Bogue Banks is a developed barrier island on the North Carolina coast.
- 22 profiles surveyed between 2016-2020 for topography and vegetation density/diversity
- Different modes of dune growth identified on managed (lateral and vertical) versus managed (fenced) profiles



Methods / Modeling Approach

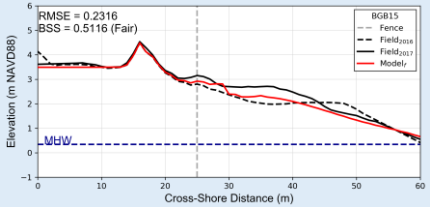
Combine process-based modeling (Windsurf) with machine learning models (Neural networks, genetic algorithms)

- Windsurf can provide accurate predictions of how the dune and beach is changing but is difficult to calibrate and computationally demanding
- Pairing Windsurf with machine learning techniques provides and efficient calibration process *and* allows the production of longer-term (annual-interannual) forecasts



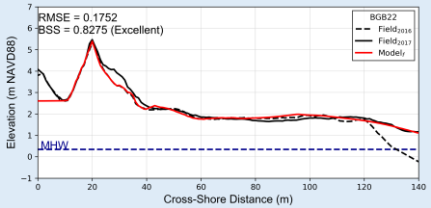
Hindcasts

BGB15



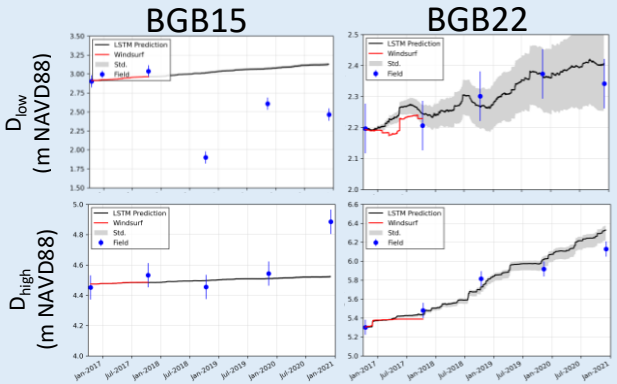
- ✓ Fenced-natural dune growth
- ✓ Beach accretion

BGB22



- ✓ Vertical dune growth
- ✓ Shoreline progradation
- × Lateral dune growth

Forecasts



- Forecasts of changes to morphology accurate out to 3-4 years
- Identifies erosion and recovery periods
- Limited predictive power when extreme change occurs outside of the training (hindcast) period (i.e., D_{low} for BGB15)
- 10 additional forecasts with random noise ran to determine forecast ranges

Conclusions

1. Dunes grew vertically and laterally on unmanaged beaches, but maintain their morphology while a fenced dune forms on managed beaches
2. Windsurf replicated each of the observed forms of dune and beach change except for lateral dune growth
3. Combining process-based and data-driven models allowed for more accurate and efficient calibration and produced accurate interannual forecasts of morphology change

Acknowledgements:
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Reference:
Cohn et al. (2019), Exploring marine and aeolian controls on coastal foredune growth using a coupled numerical model, Journal of Marine Science and Engineering, 7 (13), doi: 10.3390/jmse7010013