Deterministic, dynamic model forecasts of storm-driven erosion

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Rick Luettich [2], Matthew Bilskie [3], Davina Passeri [4], RC Mickey [4]

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Beach/Dune Erosion impacts Infrastructure

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- More frequent, high-intensity storms
- Significant storm-driven erosion leaves coastal communities more vulnerable

[LUIS SANTANA | Tampa Bay Times]

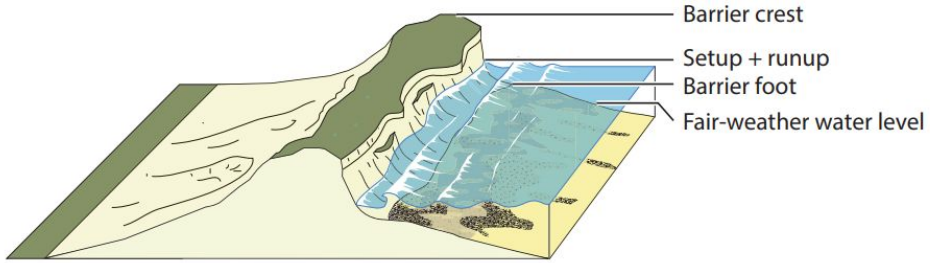
Bonita Beach, FL
Post Hurricane Ian

- Dune height: ~ 2m
- Max WL: ~1.4 m
- Max Hs: ~5.5 m

Sallenger (2000) Impact Regimes

Collision regime

$D_{low} < R_{high} \ll D_{high}$



Goslin & Clemmensen (2017)

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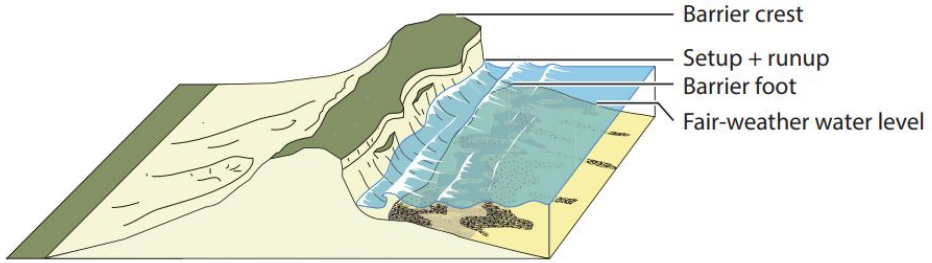
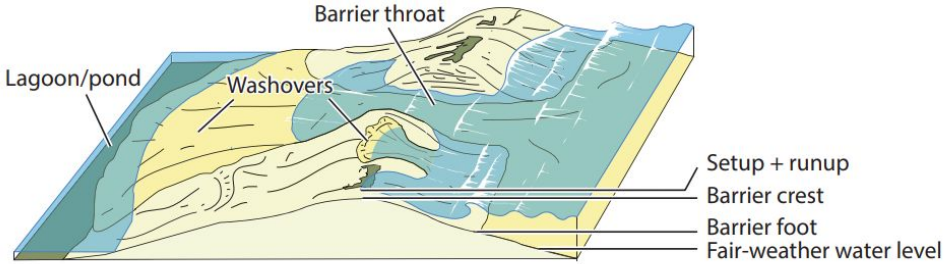


Overwash regime

$R_{high} > D_{high}$



Goslin & Clemmensen (2017)

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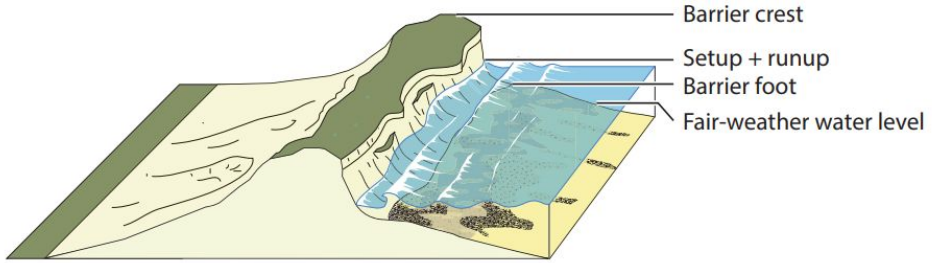

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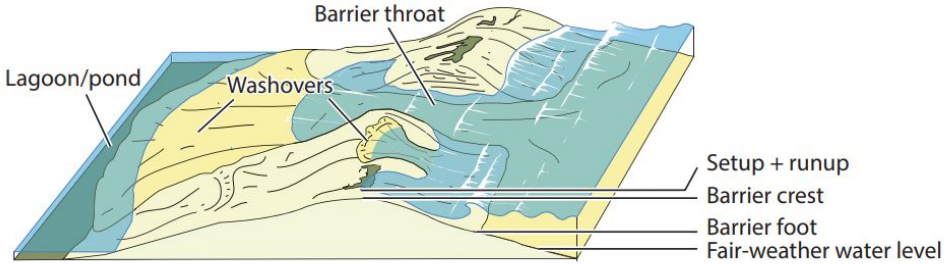
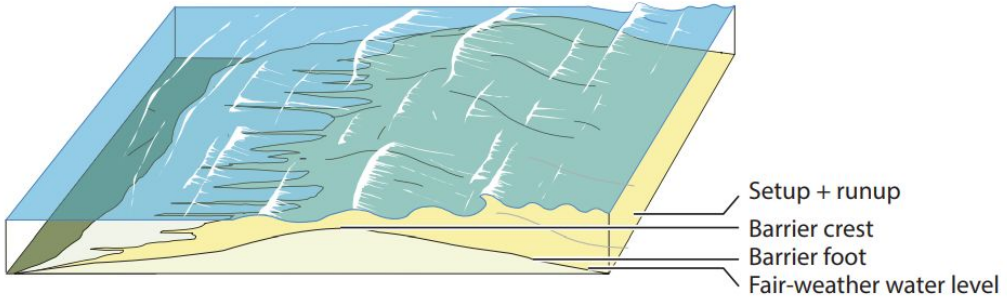


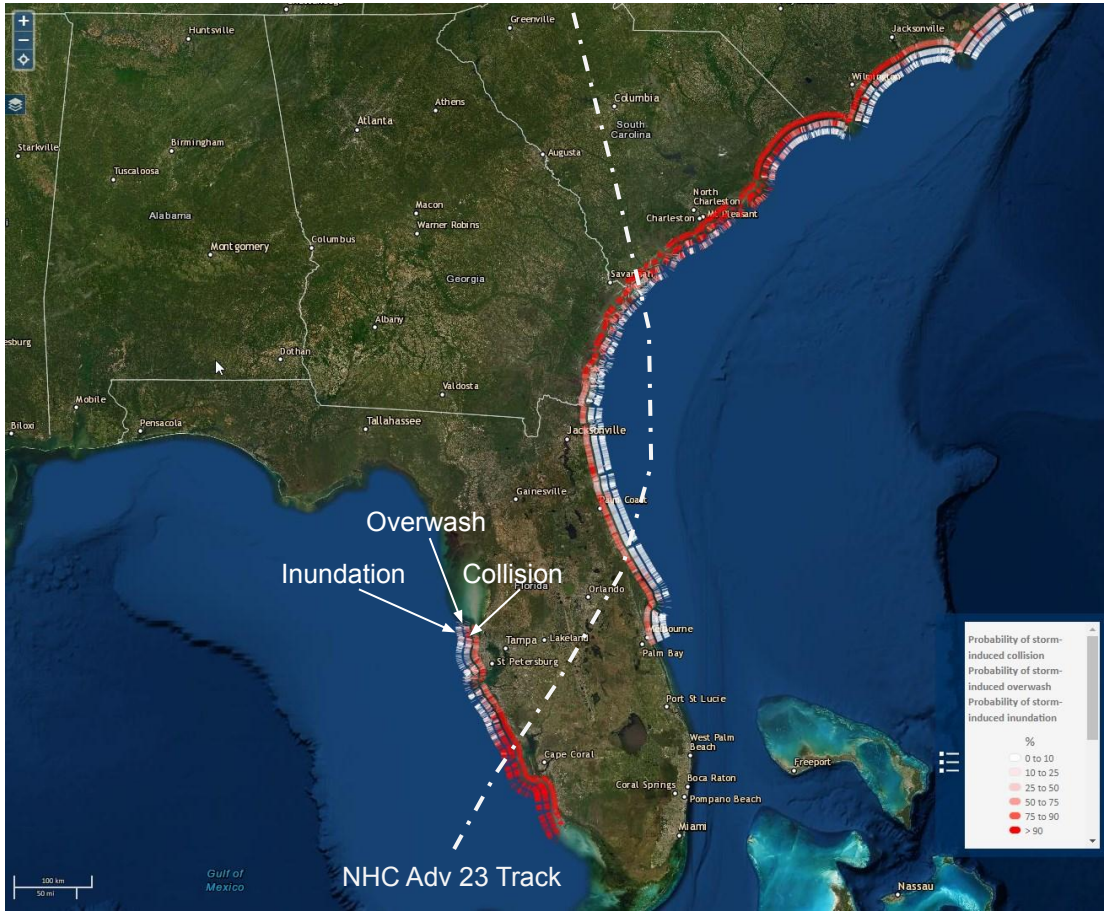
Inundation regime

$R_{low} > D_{high}$



Goslin & Clemmensen (2017)

Erosion Forecasts with Impact Regimes



USGS Coastal Change Hazards Portal

- Uses Sallenger (2000) impact regimes
- Based on probabilistic surge forecast (psurge) generated by NOAA
- **Static** prediction of storm impact

Erosion Modeling with XBeach

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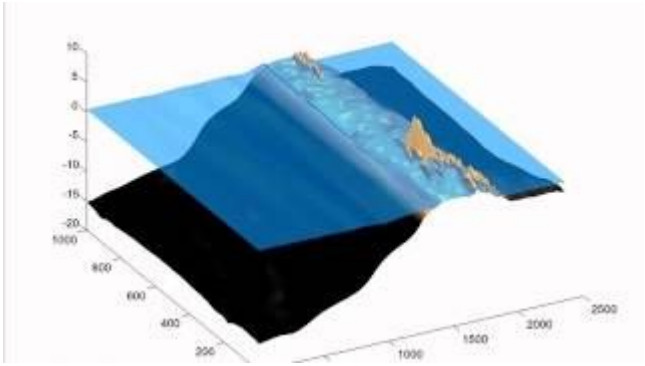
eXtreme Beach (XBeach)

- Morphological model for storm-driven erosion
- 1D or 2D options
- High resolution, dynamic results
- Typically used in hindcast scenarios
  - Data availability limitations
  - Computational expensive
  - Can take hours



XBeach-Deltares

Can **1D XBeach** be used in real time?

- Harley, M. et al (2011) did this with an 8 km stretch of coast in Northern Italy

We are attempting to represent **over 4000 km** of the U.S. East and Gulf Coast

Goal and Research Questions

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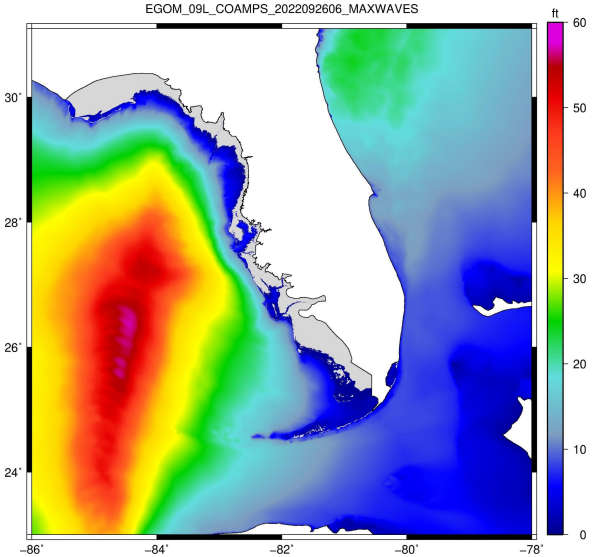
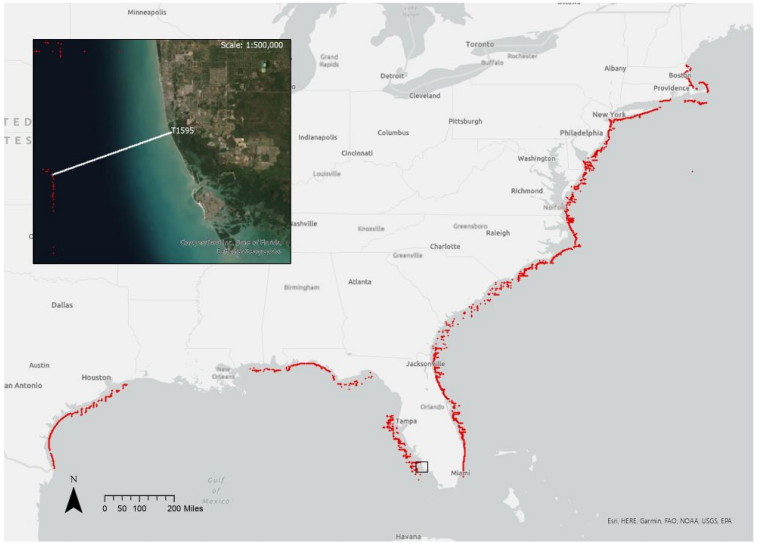
Use the morphological model XBeach to forecast storm-driven erosion along the U.S. East and Gulf Coast prior to landfall

1. How can we evaluate the predictive accuracy of the model?
2. How do our predictions improve as a storm makes landfall?
3. When during the storm is the dune impacted?

Forecasts with 1D XBeach



η, Hs, Tp, θ



[Mickey & Passeri 2022]

1D XBeach simulations

- Calibrated with NOPP collaborators (van Dongeren and team)
- Hundreds of 1D simulations in less than an hour

Examples of Forecast Guidance

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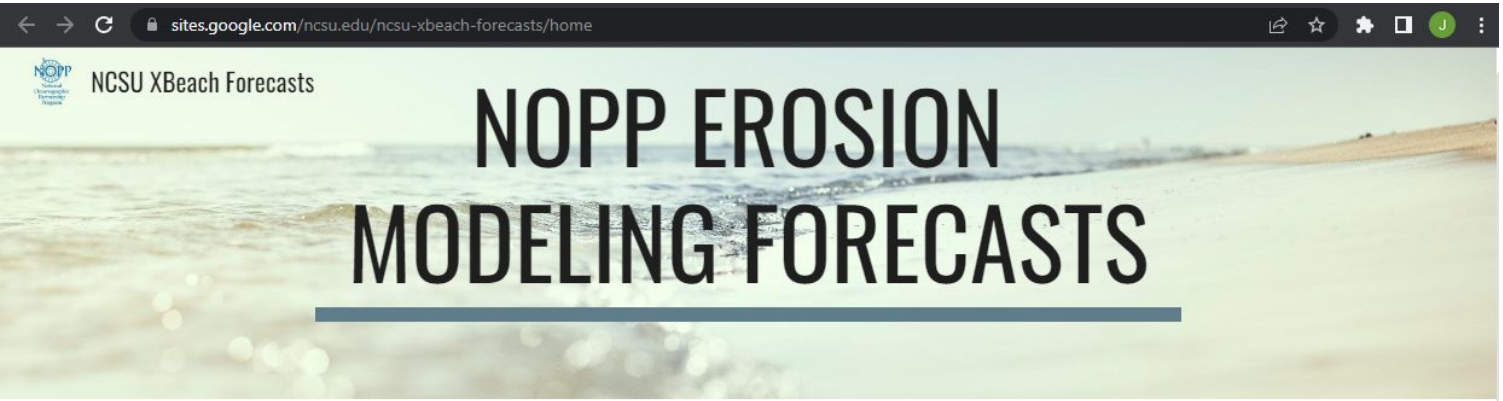

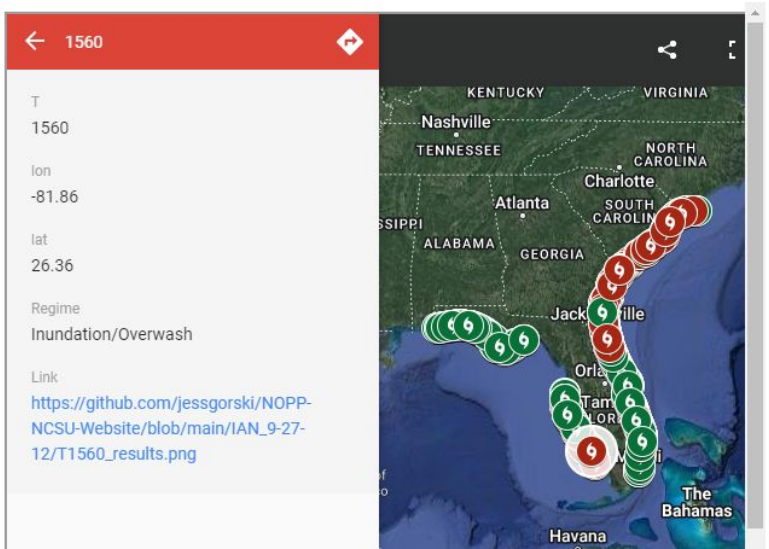

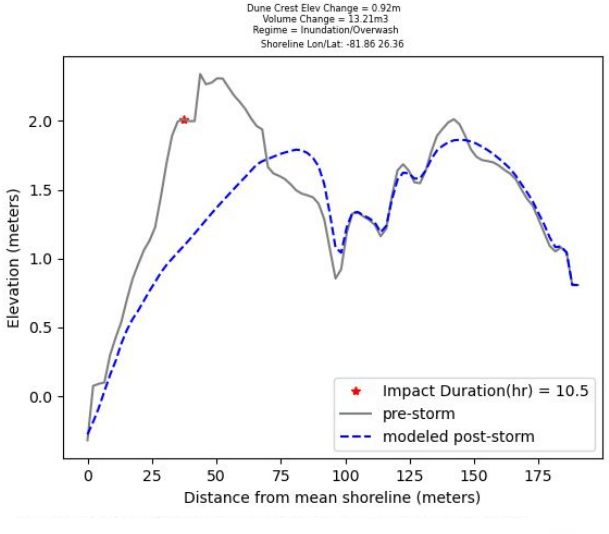

SCAN ME

Hurricane Ian

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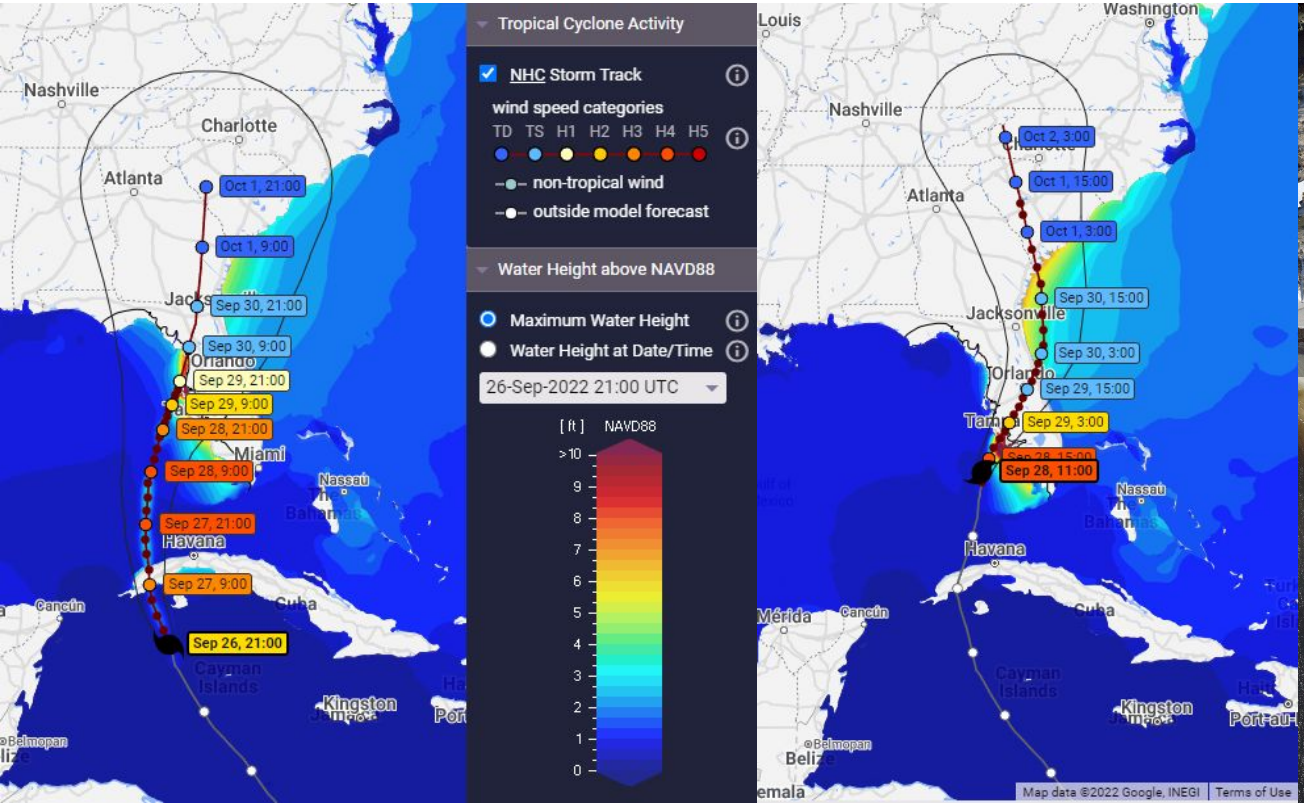
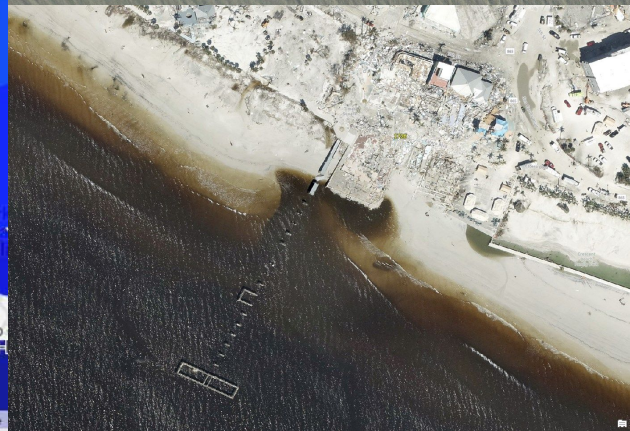
- Low-end cost estimate: $ 28 Billion
- Track originally estimated to make landfall in Tampa
  - Shifted south, made landfall in Fort Myers, moved into Atlantic, made another landfall north of Charleston
  - Adv 15 (~3 days before landfall) vs Adv 23 (~1 days before landfall)





1. How can we evaluate predictive accuracy?

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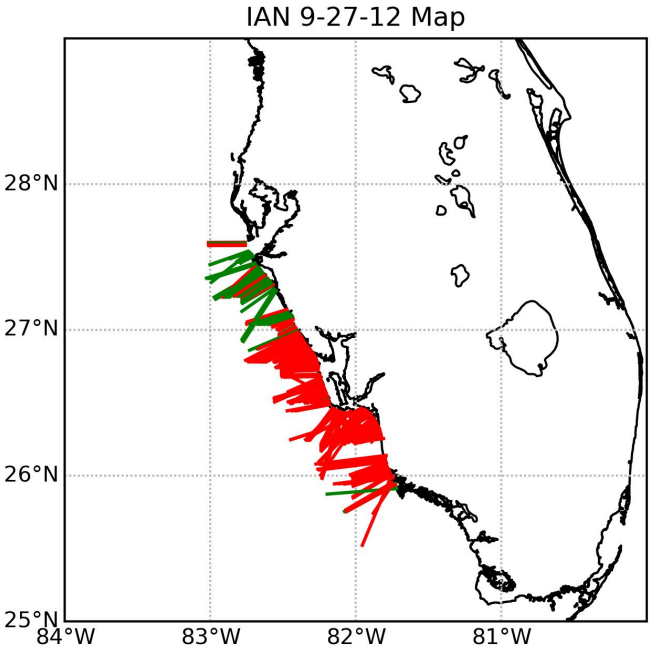
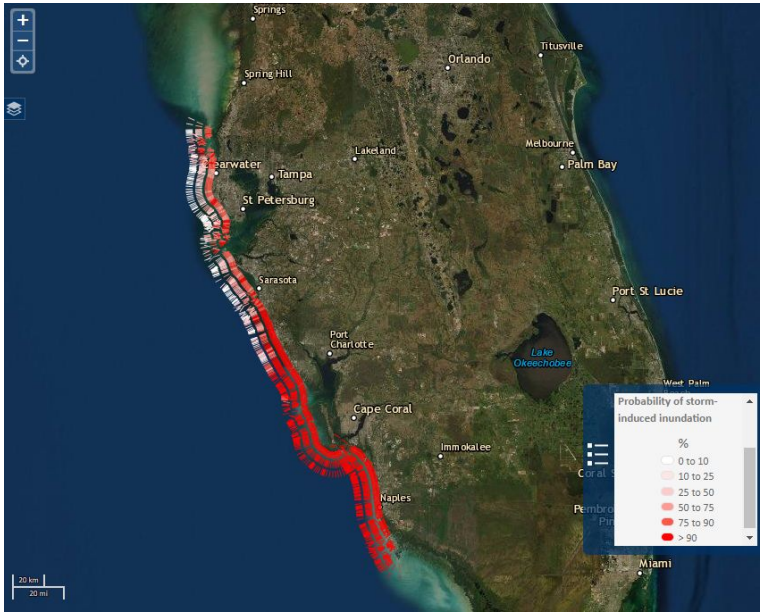
Qualitative

- USGS Coastal Change Viewer
- Aerial photos
  - 87% success rate



Quantitative

- Looking for post-storm LiDAR
  - Compare pre- and post-storm transect elevation data



2. How do forecasts improve as a storm makes landfall?

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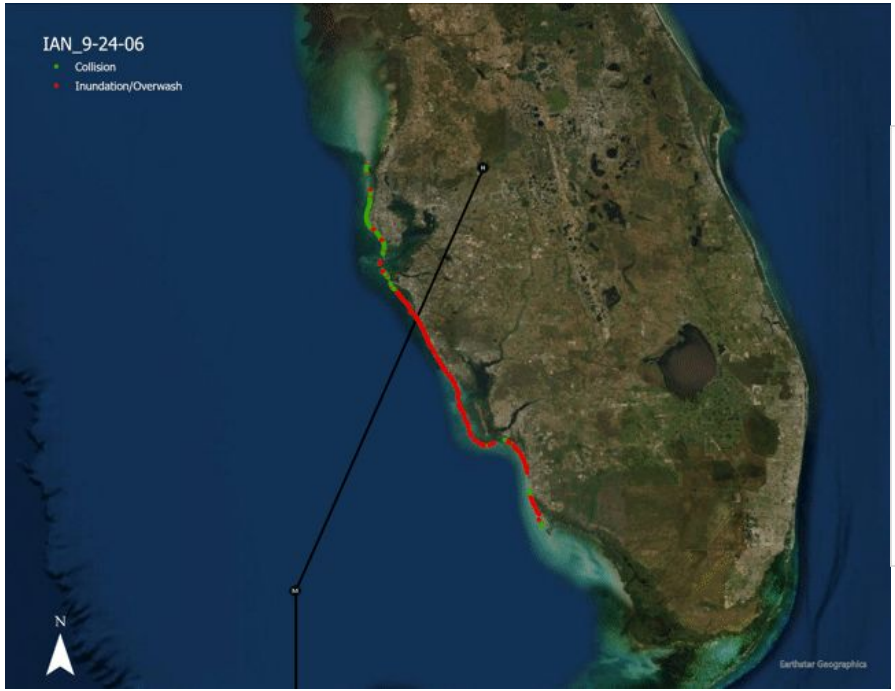

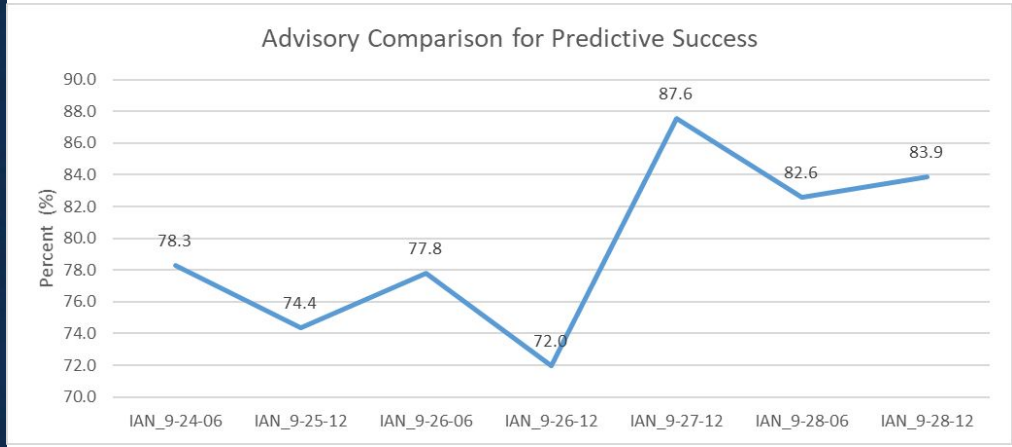

3. When during the storm is the dune impacted?

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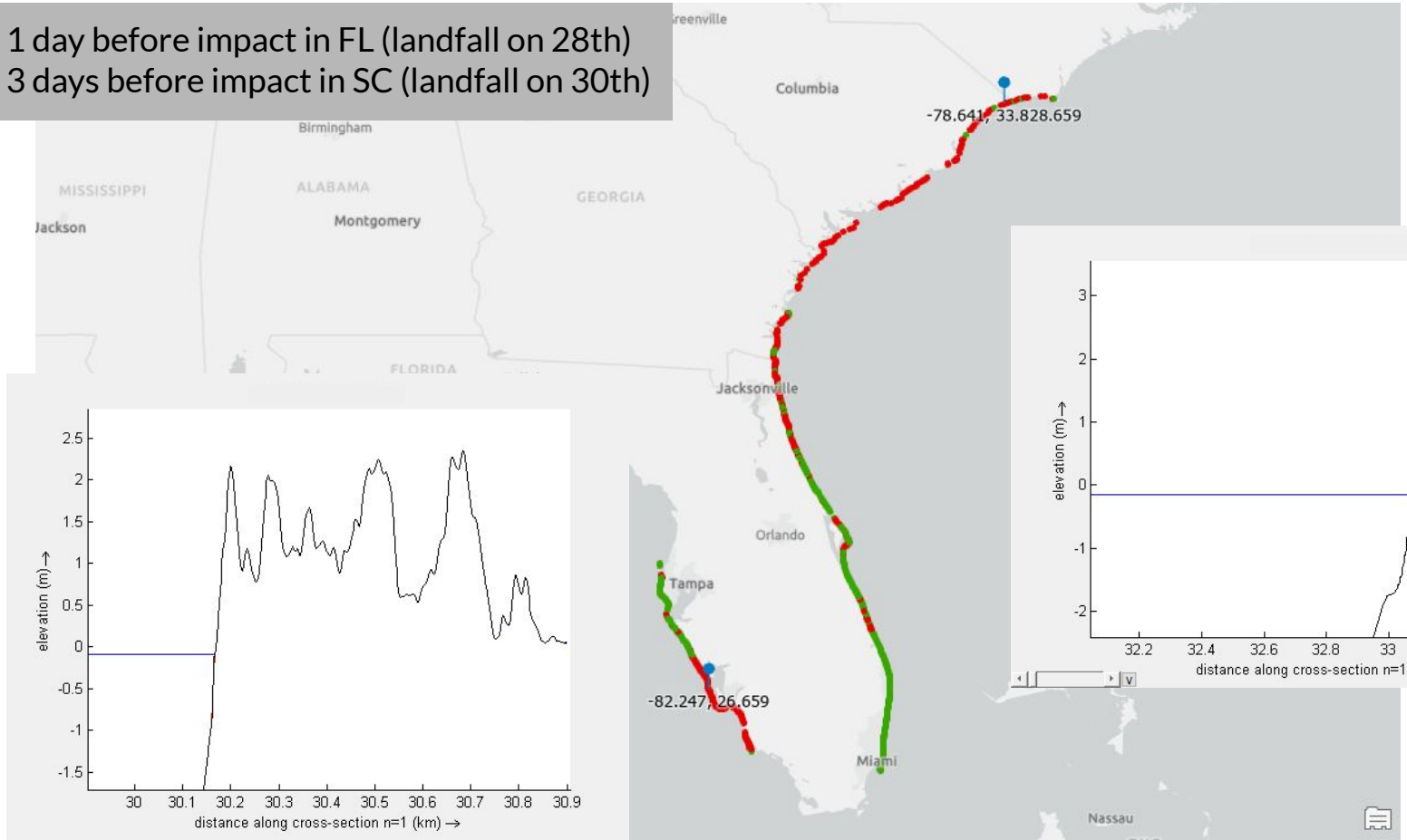
~ 1 day before impact in FL (landfall on 28th)
~ 3 days before impact in SC (landfall on 30th)



Conclusion

1. How can we evaluate the predictive accuracy of the model?
    a. Approximately 87% predictive success rate
    b. Looking for post-Ian elevation data for quantitative evaluation
2. How do our predictions improve as a storm makes landfall?
    a. Impact predictions improve from 72% on 9-26 to 87% on 9-27
3. When during the storm is the dune impacted?
    a. Dynamic erosion models show storm progression

SCAN ME

Citations

Slide 2:

https://www.tampabay.com/hurricane/2022/09/30/friday-live-updates-florida-recovers-hurricane-ian-targets-carolinas/

Slide 3: Goslin J, Clemmensen LB. 2017. Proxy records of Holocene storm events in coastal barrier systems: stormwave induced markers. Quat. Sci. Rev. 174

Slide 4: https://marine.usgs.gov/coastalchangehazardsportal/

Slide 5: https://www.deltares.nl/en/software/xbeach/

Harley, M., Armaroli, C. and Ciavola, P., 2011. Evaluation of XBeach predictions for a real-time warning system in Emilia-Romagna, Northern Italy. Journal of Coastal Research, SI 64 (Proceedings of the 11th International Coastal Symposium), – . Szczecin, Poland, ISSN 0749-0208

Slide 8: NOPP slides made by Rick Luettich and Matt Bilskie

Slide 11: https://cera.coastalrisk.live/

https://www.cnn.com/2022/09/30/business/hurricane-ian-cost