Long-Term Morphological Evolution Model

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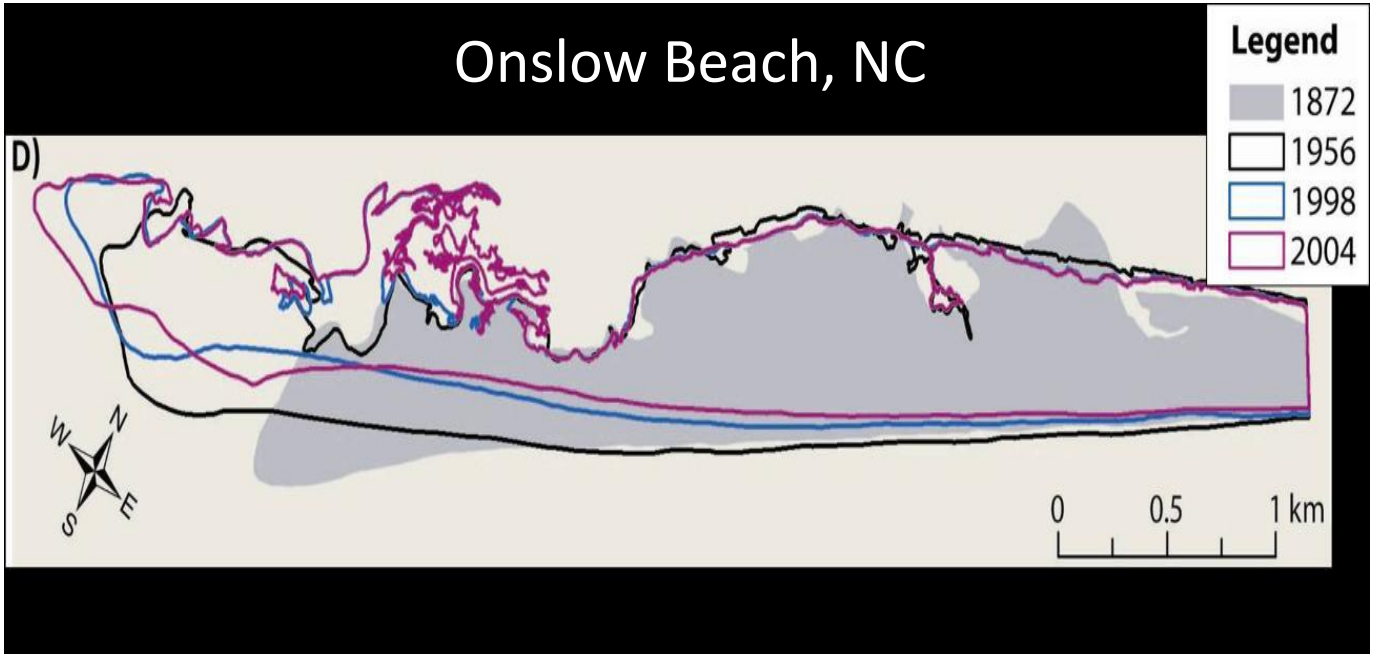
Objectives –

- Introduce a simplified numerical shoreline model (CSHORE-C15) with process-based sediment transport calculations including nearshore and swash with a response to changes in forcing conditions on an hourly basis, yet can be used over longer, management-relevant time periods.

- Demonstrate model skill with 20-yr hindcast model exercise

Motivation



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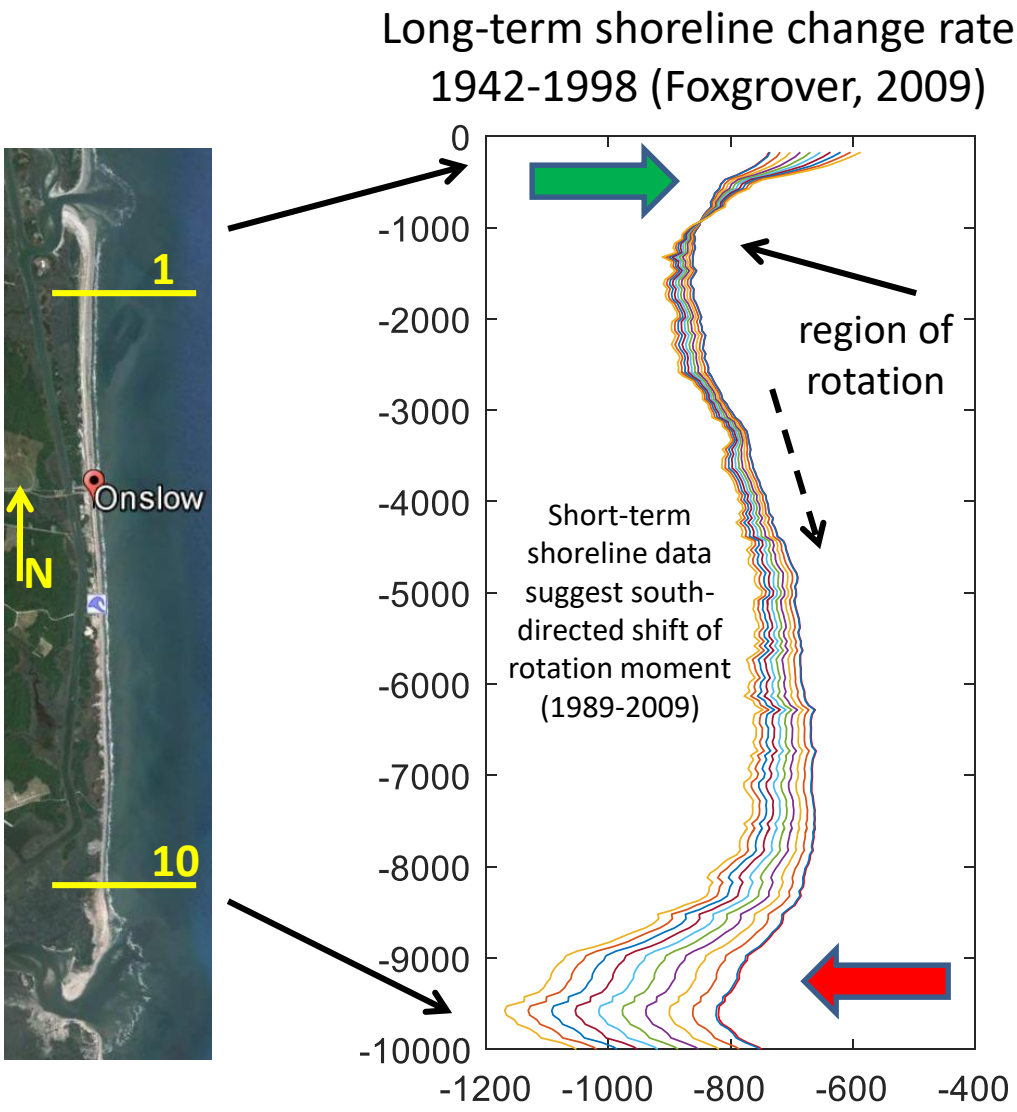
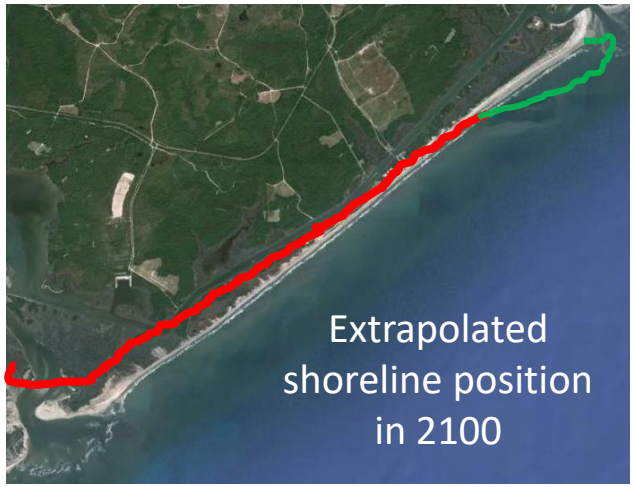
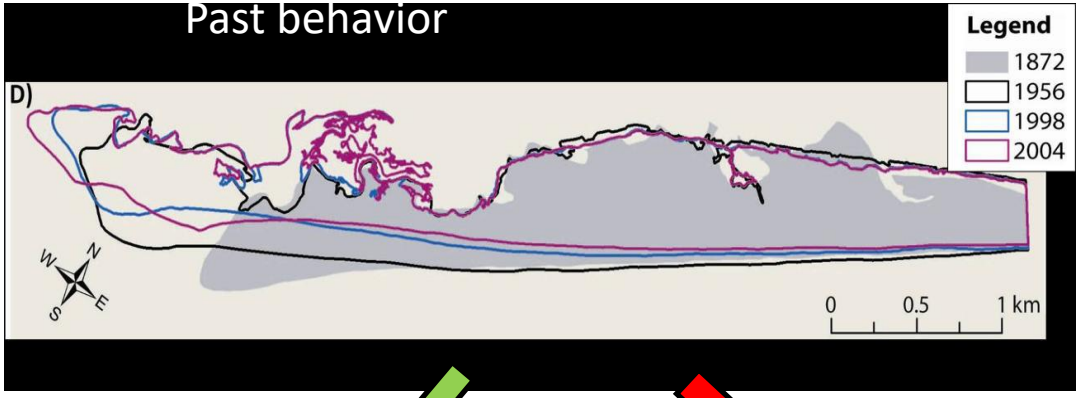
- ~10 km of sandy beach
- US Marine training ground is threatened
- Recession of shoreline in South
- Accretion on North
- Swash and Overwash relevant
- Forecast will require variations in sea level and storm climate

Extrapolated Shoreline: +100yr





Motivation



Efficient Model with Some Processes

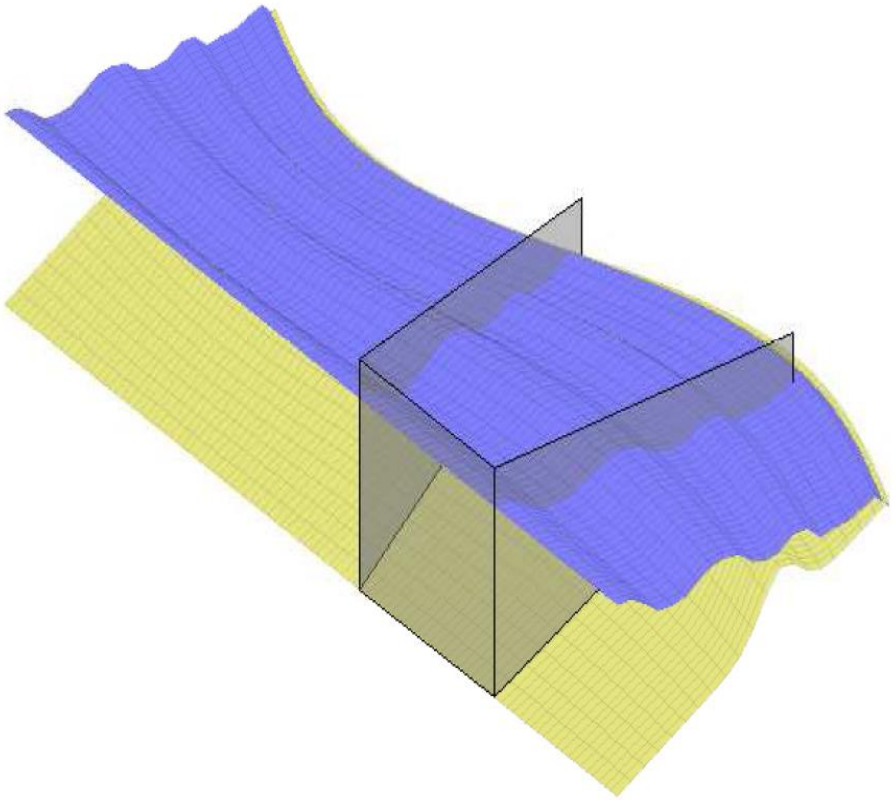
Linear Extrapolation

Existing evolution models

- **One-line (or n-line models) do not include profile changes and overwash**
- **Phase-averaged 2DH models lack swash, computationally expensive**
- **Low frequency-resolving models prohibitively expensive**

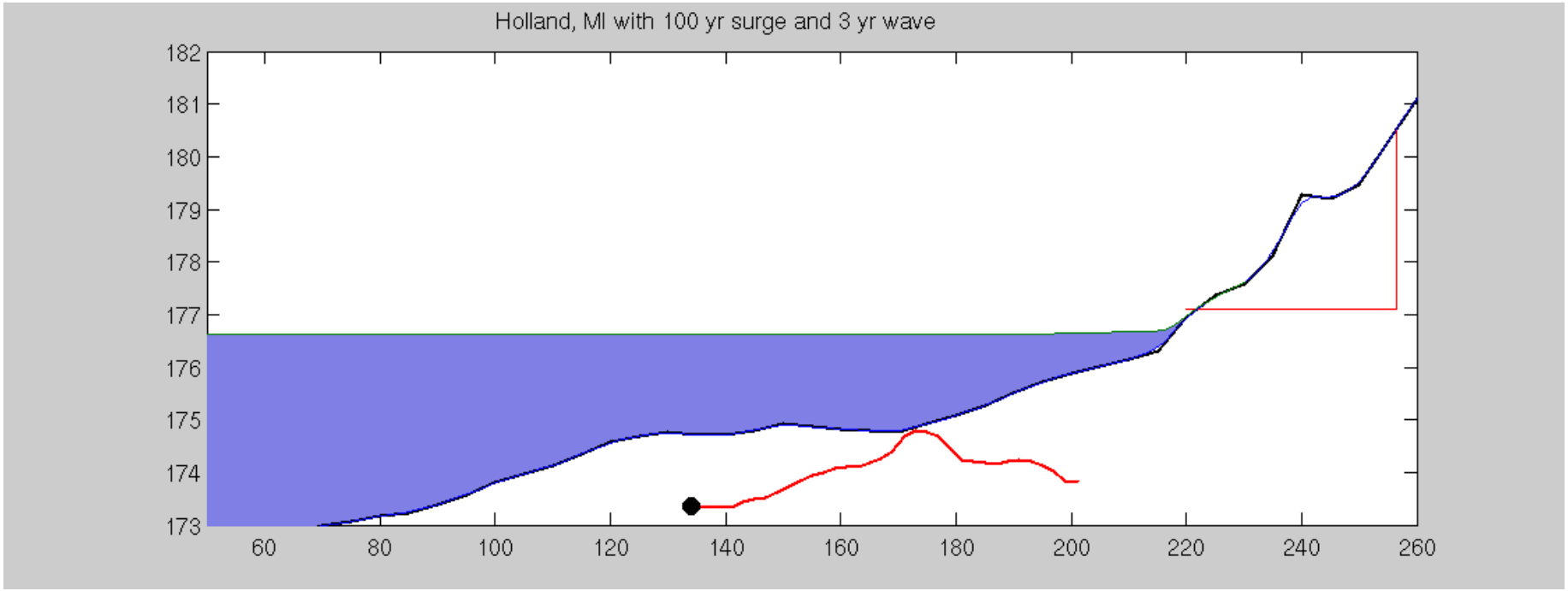
CSHORE-C15
-- a new approach

- Use CSHORE to compute profile evolution, builds on growing confidence in profile modeling
- Multiple profiles, each assumed longshore uniform
- Run-time is linear with domain size
- Parallel implementation



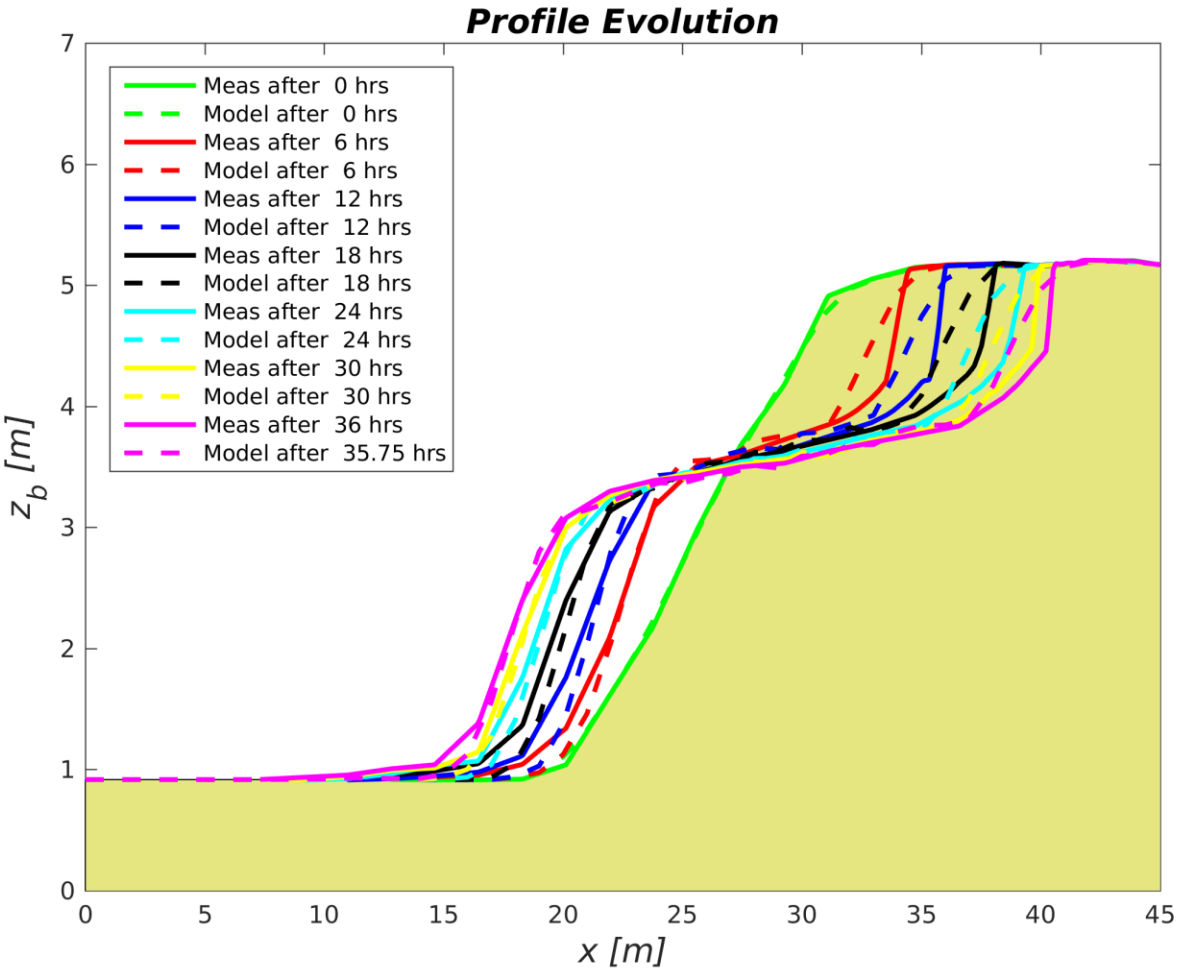
1-D Profile Model-Short scale

- Shallow Water Hydrodynamics driven by Waves
- Probabilistic Sediment Transport
- Representation of the Swash Zone and Overtopping
- Includes Erosion and Accretion Mechanism
- Allows Obliquely Incident Wave-Driven Transport



CSHORE Profile model results

- No Onslow beach profile evolution data exist
- Some faith in the erosion model accuracy
- OSU test named GEE with 36 hours of erosive conditions is an example comparision

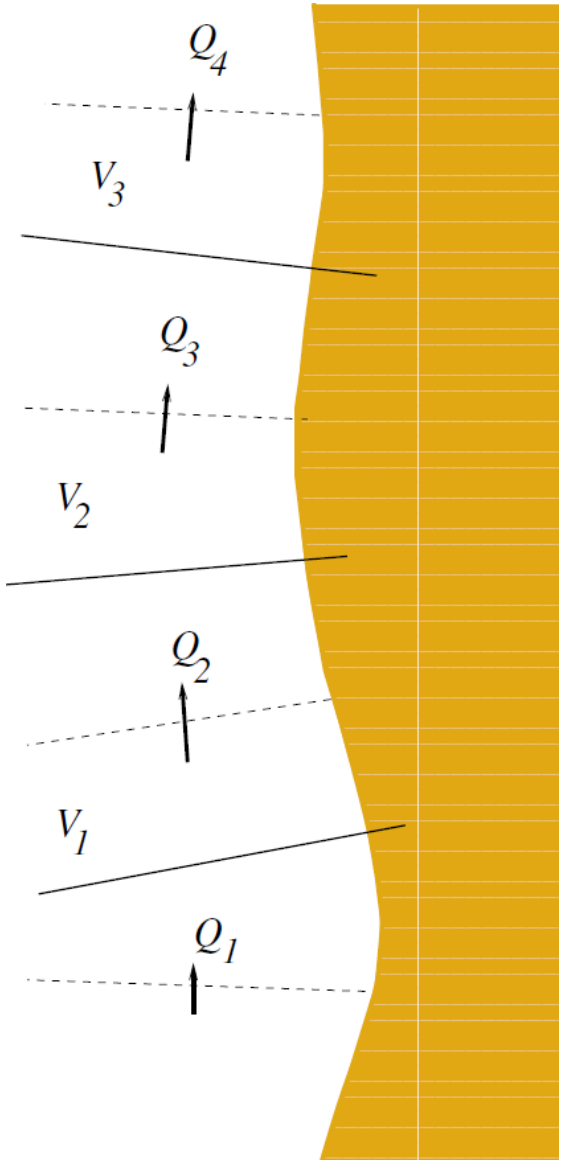


2-D Shoreline Model-Long scale

- **Cross-shore evolution (fast time-scale) informs the longer-term evolution**
- **Longshore balance due to conservation statement:**

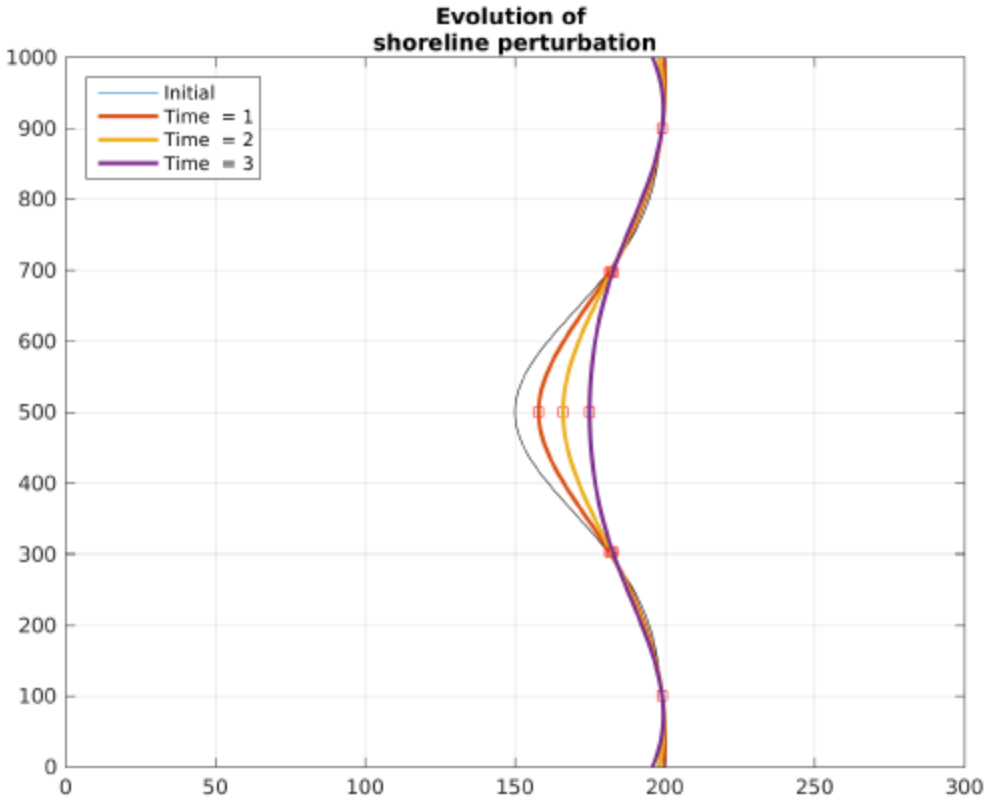
$$\frac{\partial V_i}{\partial t} = Q_i - Q_{i+1}$$

- **Used center-cell staggered grid**
- **Profiles are translated to achieve computed volume changes**

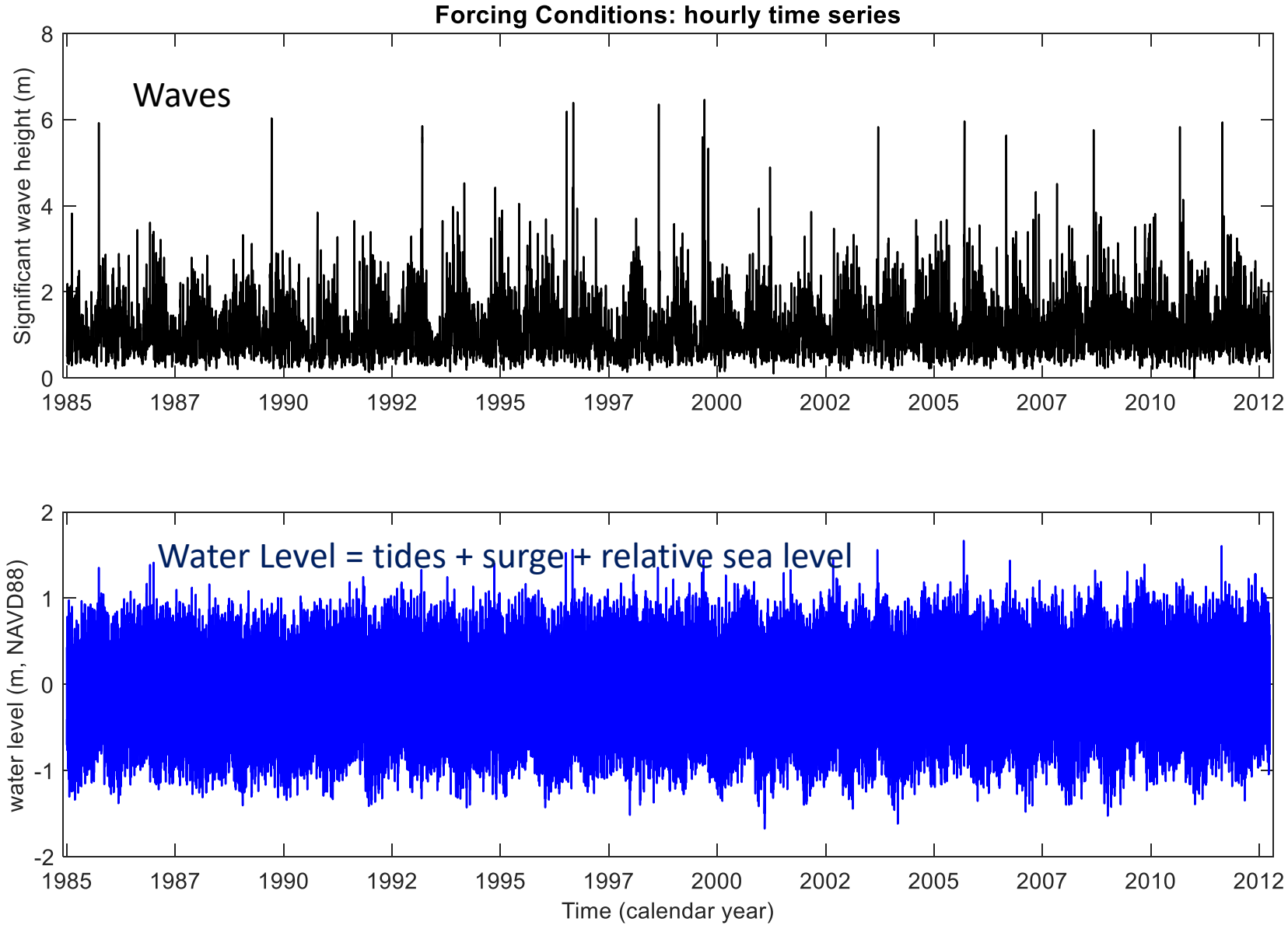


2-D Shoreline Model

- **Initial Gaussian Perturbation**
- **Model smoothes like diffusion eqn.**



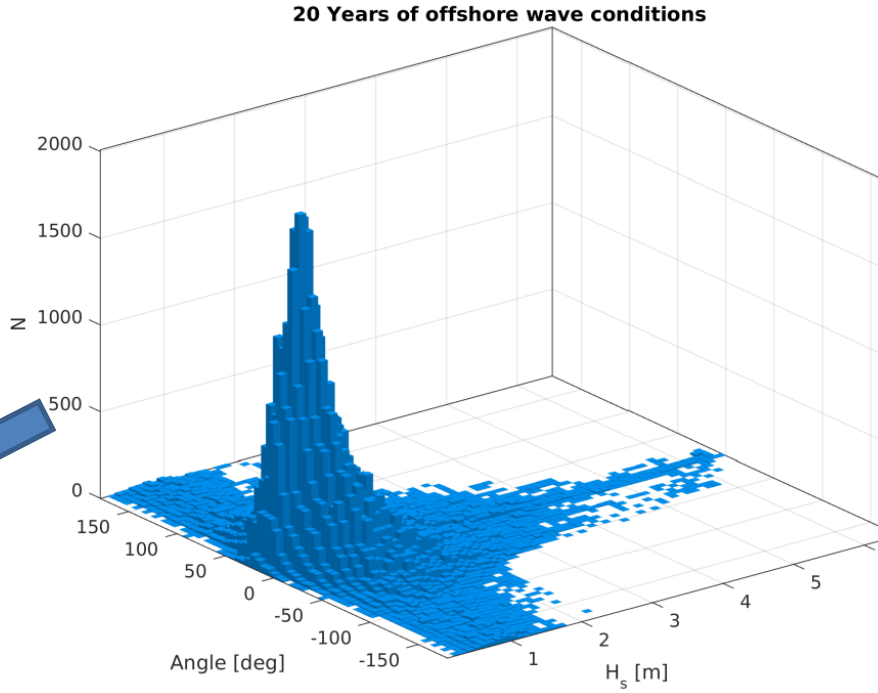
Observed Forcing Conditions used in Model

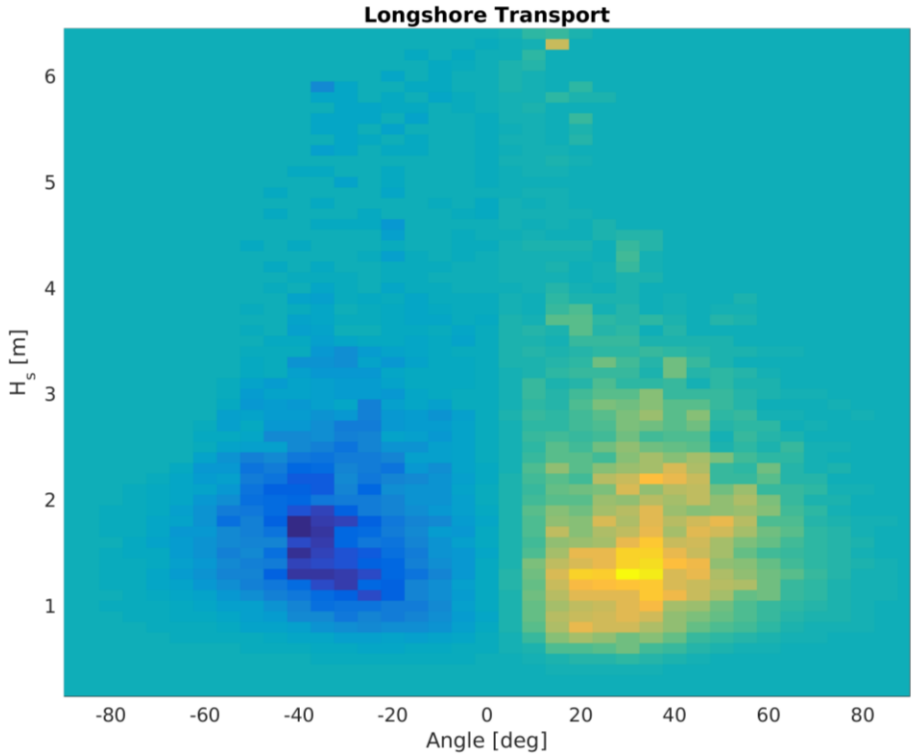


Waves and Longshore Sediment Transport

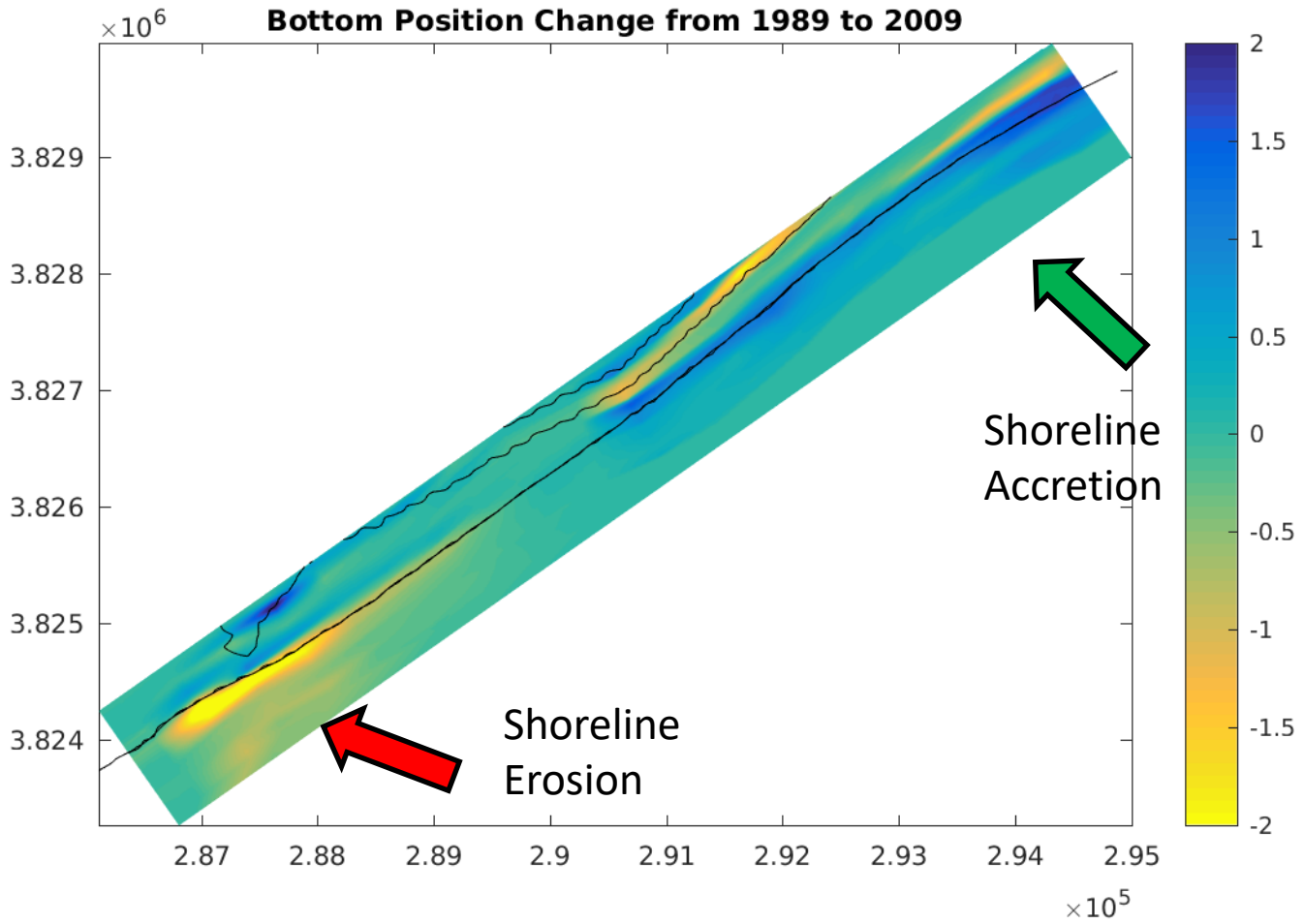
-- balanced angle and height distribution generates balanced LST power

$$Q \propto H^{5/2} \sin(2\alpha)$$



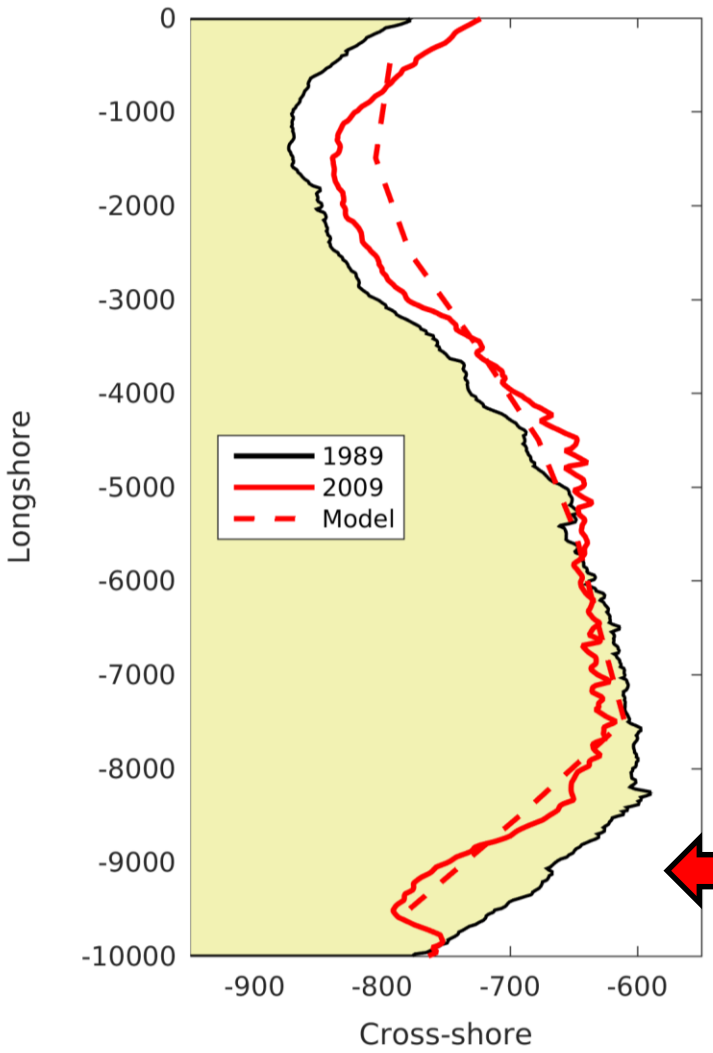


Morphology Change



Longshore Transport and Shoreline Change

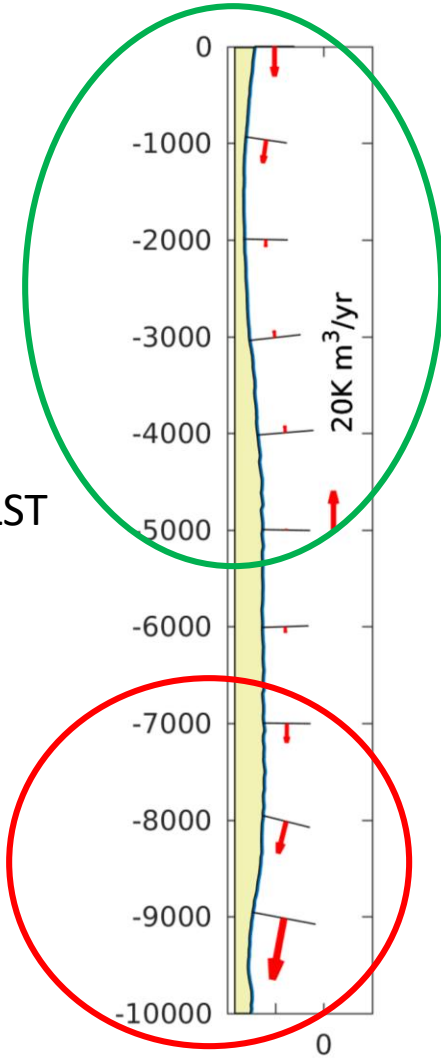
-- modeled, average annual LST



Region of LST convergence explains accretion

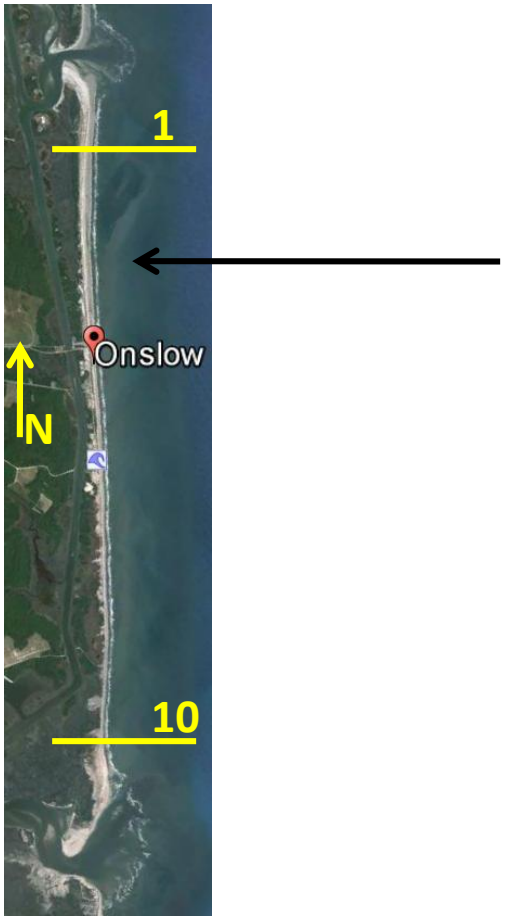
Region of minimal LST explains minimal change

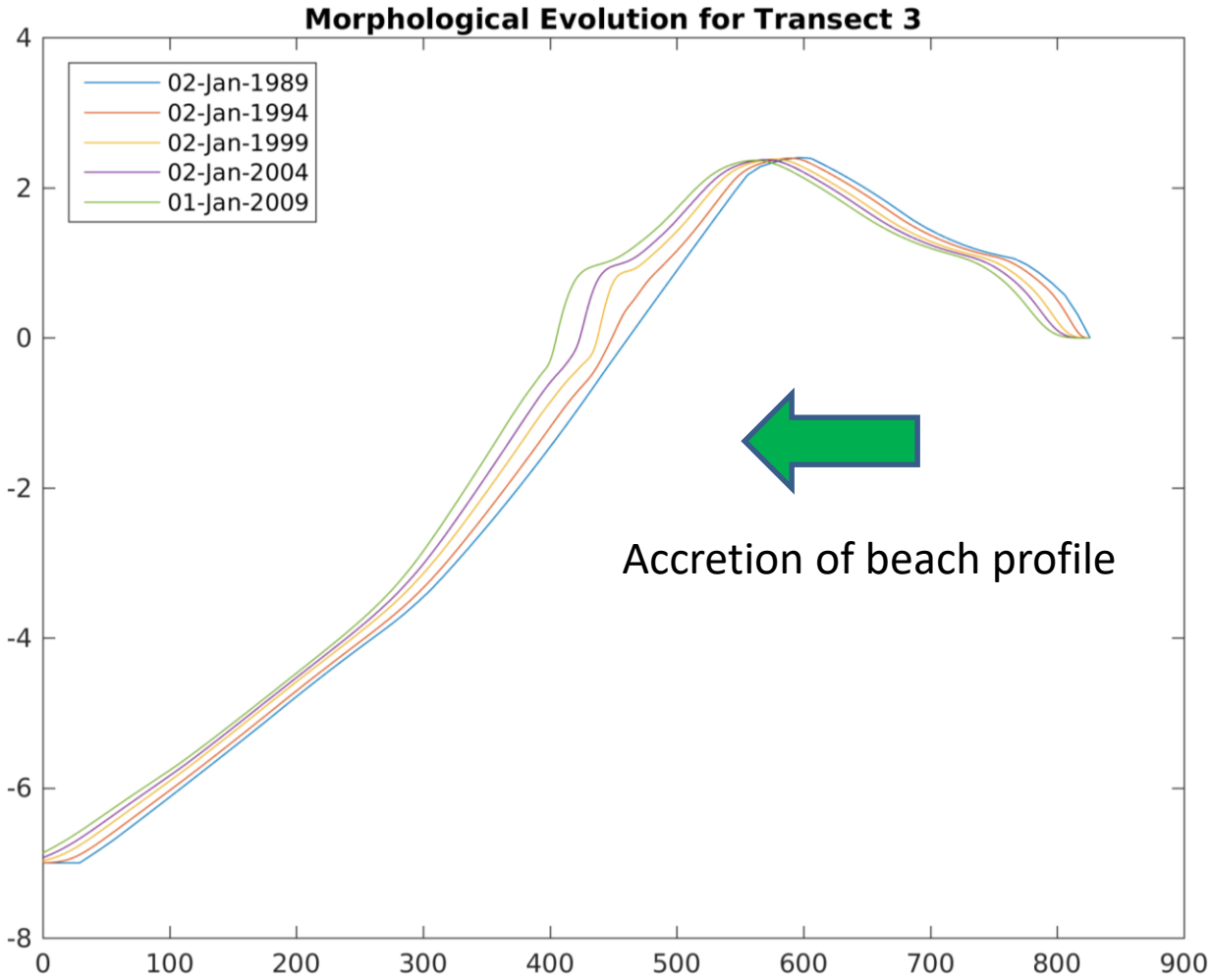
Region of LST divergence to south explains erosion and inlet migration



Modeled Profile Evolution

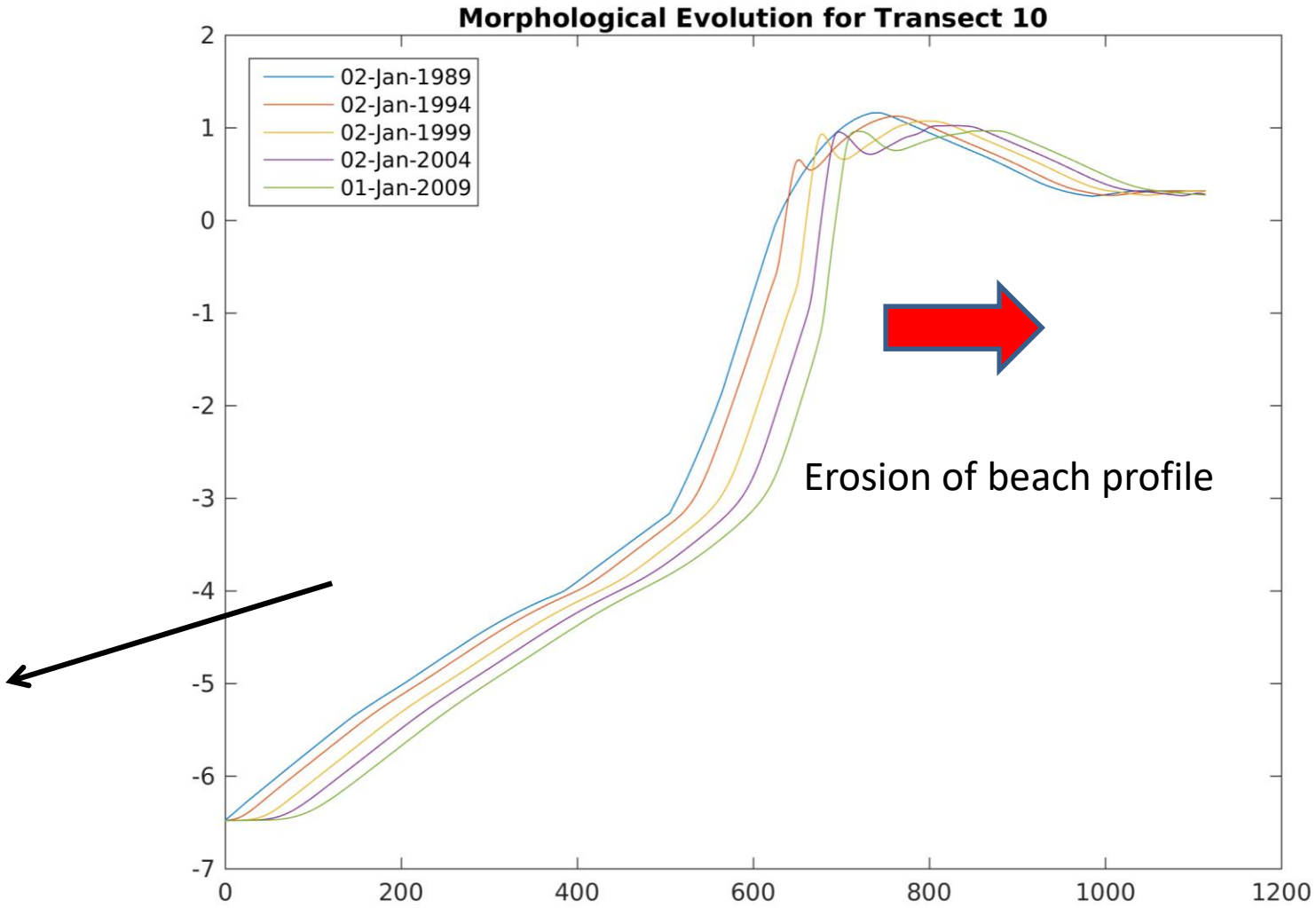
-- profile accretion, un-scarped dune





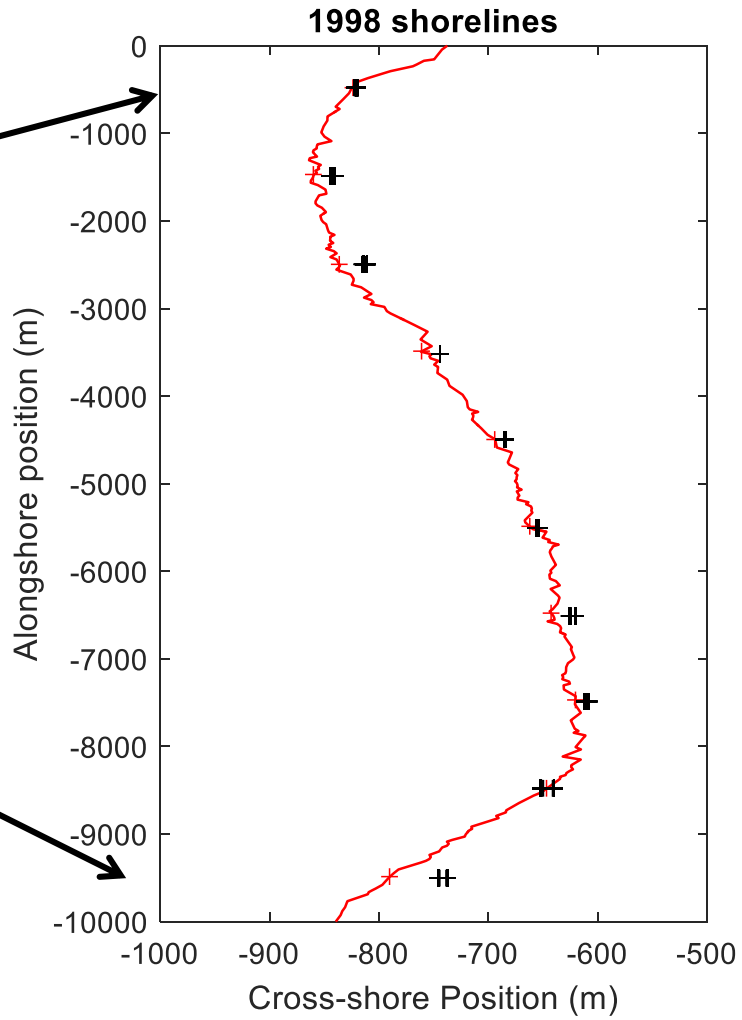
Modeled Profile Evolution

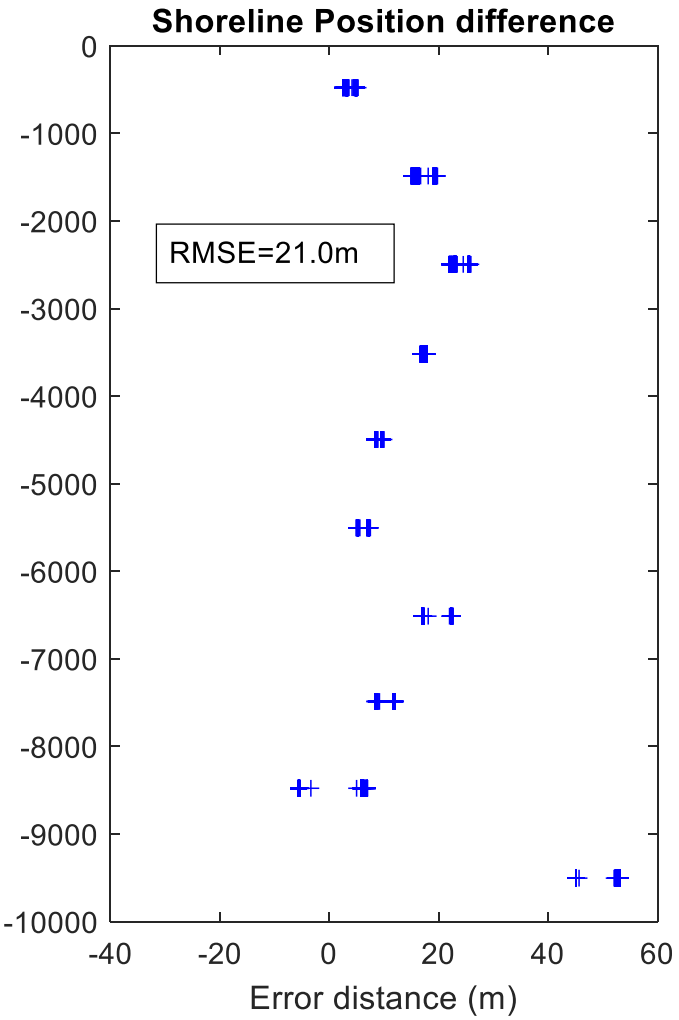
-- profile erosion, lowering and dune overtopping



Modeled Shoreline Position: 1998

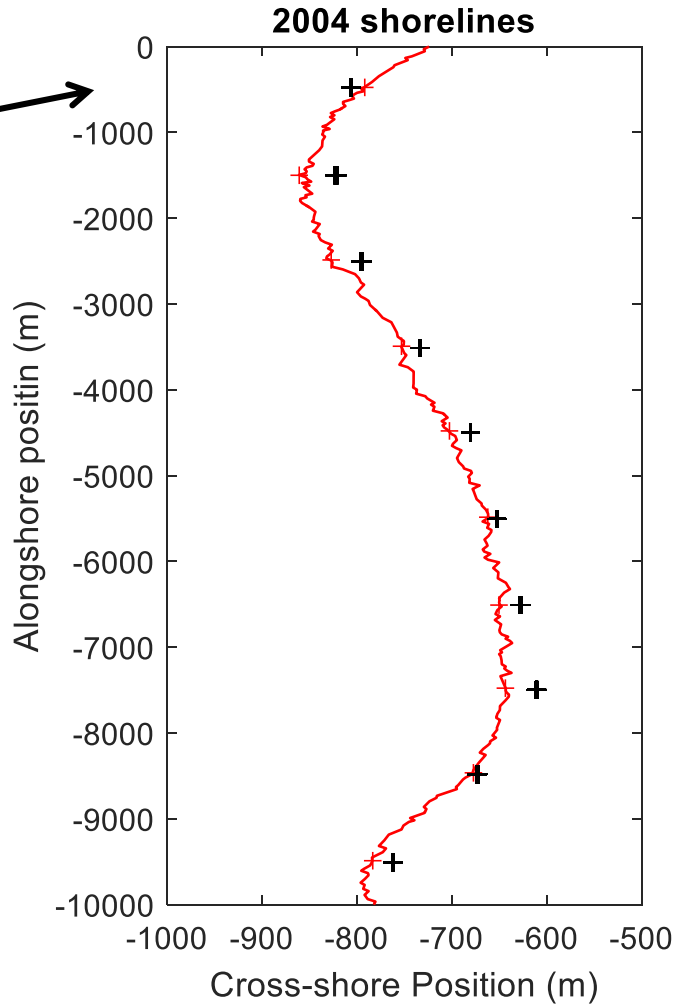
-- after +9 years of hourly, cumulative solutions (no resetting or tuning)

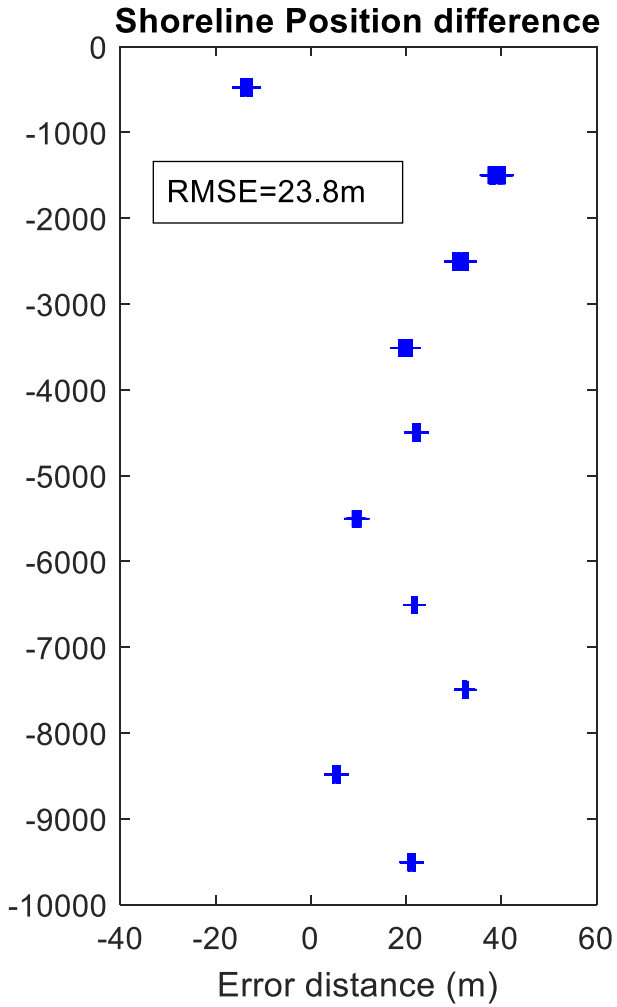




Modeled Shoreline Position: 2004

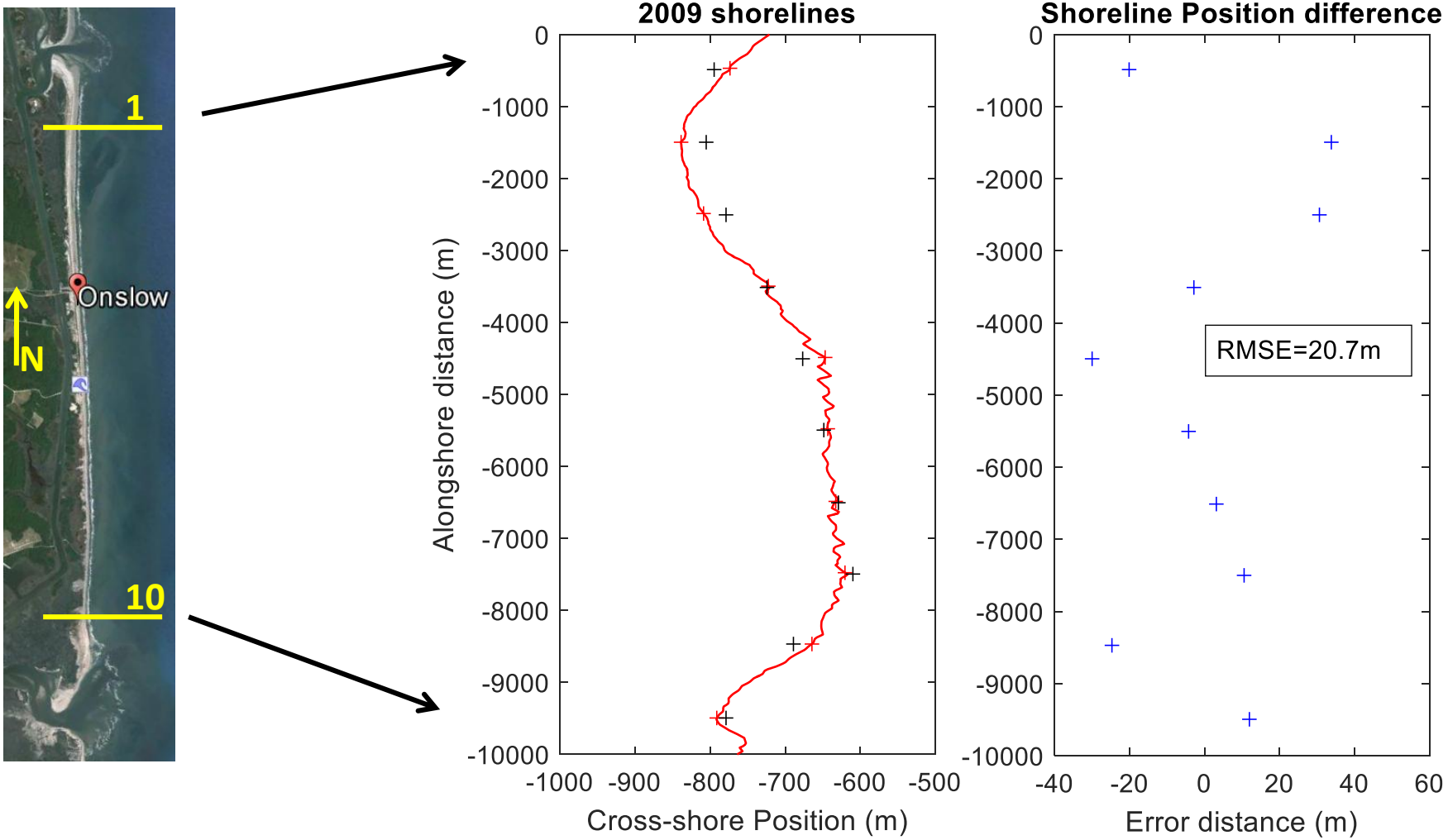
-- after 15 years of hourly, cumulative solutions (no resetting or tuning)





Modeled Shoreline Position: 2009

-- after 20 years of hourly, cumulative solutions (no resetting or tuning)



Summary Findings

- Extrapolation of historic shorelines **does not**:
  - Evolve dunes and beach topography
  - Respond to changes in relative sea level rate
  - Respond to changes in climate forces or geology (evolving bathymetry)

- No other existing model has the processes and efficiency necessary to simulate morphology stochastically over long time periods (climate relevant)
  - Model 20 yrs in about 6 hours

- Longshore transport is nearly balanced over long times

- Hindcast shoreline model within factor of 2
  - Predict 100 m (data:50m) of accretion on North
  - Predict 50 m (data:50m) of erosion on South