

Synopsis:
To resolve or not to resolve?
To nest or not to nest?
Seems best not to.
(in some cases at least)

Don't Upscale the Coastline: Scales of Cumulative Change Emerge

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 WHERE DISCOVERIES BEGIN

Biocomplexity/CNH
 Geomorphology and Land-Use Dynamics

Conclusion:
Treat emergent dynamics when available
(like fluid dynamics vs. molecules)
More insight, and large-scale results may
not depend on small-scale processes
(e.g. could be worms or ice lenses...)

Intro: Coastline Change: many scales
Where to start??

- Action during storms!
- Transport starts w/waves, grains, ripples
 millimeters – meters; seconds - hours
- Ripples affect currents, bars, etc.
 10s m – km; hours – days
- For large scale, long term,
 start w/small?

Observations suggest no



small



medium

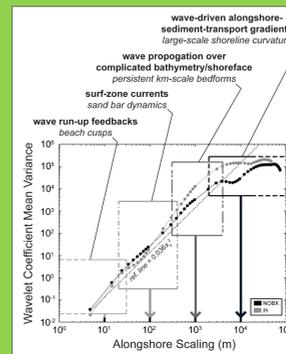


large

How to model
 Coastline evolution.
 Chronic erosion??

Interpretation: Coastline diffusion at large scales

- Behaviors differ w/ scale
- At smaller scales,
 timescales < yrs,
 independent undulations
- At larger scales,
 diffusion dominates
 (change \propto curvature)



Alongshore Sediment Flux, Q_s :
 $Q_s = K_2 H_0^{12/5} \cos^{6/5}(\phi_0 - \cdot) \sin(\phi_0 - \cdot)$

waves
 Q_s
 shore—plan view

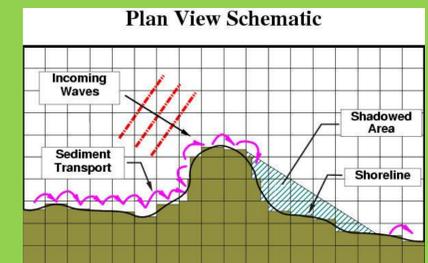
C. of nearshore
 Sediment:
 $\partial\eta/\partial t = (-1/D)\partial Q_s/\partial x$

eros., accretion
 cross section

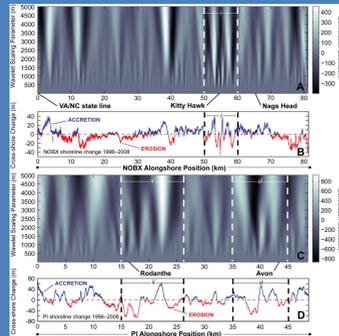
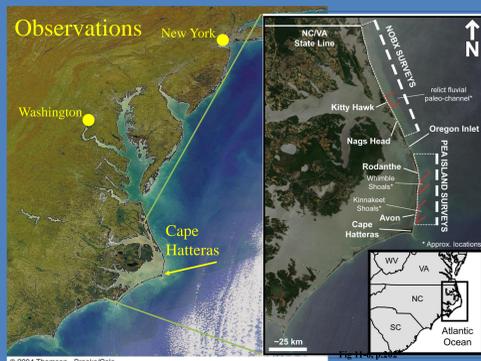
$\rightarrow \partial\eta/\partial t = (1/D) K_2 H_0^{12/5} \{f(\text{wave angle})\} \partial^2\eta/\partial x^2$
 for large alongshore λ or short-period waves (shore- \parallel contours)

Modeling large scale dynamics directly:
diffusion, antidiffusion, and finite amplitude behaviors

- Discretize alongshore sediment flux, C. of mass
- Variables limited to:
 - Shoreline orientation (on scales \sim km)
 - 'Deep-water' wave height, direction
 - (No ripples, bars, channels...)
- Partly rule-based (wave shadowing;
 coupling wave models soon)

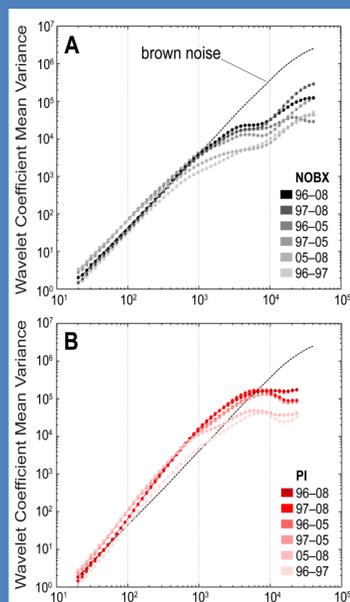


Observations: Large is different than small



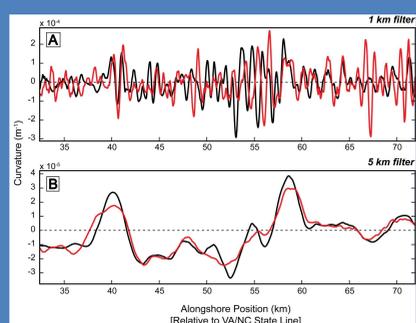
Results

- small scales (< \sim km):
 var. independent of duration
- Larger scales (kms):
 change increases w/time;
 var. maxima, 4 – 8 km;
 scale of max. increase w/time;
 scaling consistent w/diffusion
 (4 km \rightarrow T \approx 3 yrs;
 10 km \rightarrow T \approx 16 yrs)

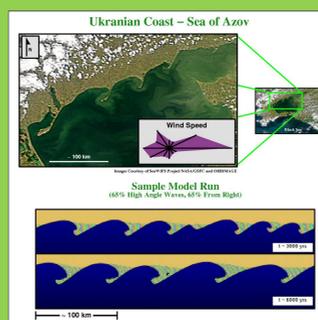


Shoreline smoothing—
 at large scales

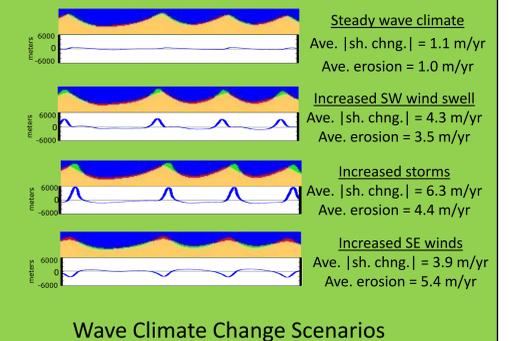
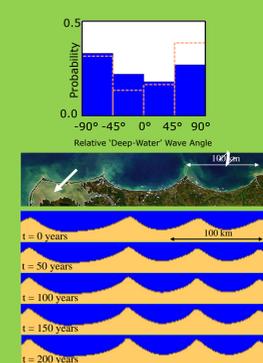
Results black = 1996 red = 2005



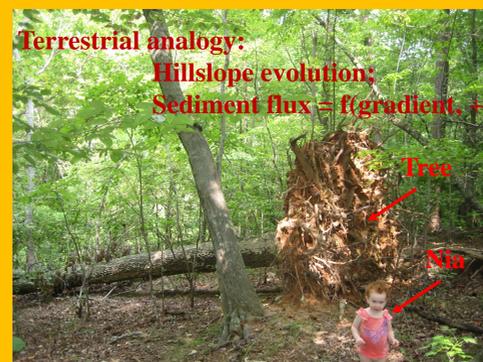
e.g.:



Changing storm climates



Terrestrial example: modeling hillslope evolution



Terrestrial analogy:
 Hillslope evolution;
 Sediment flux = f(gradient, ...)



Flux from:
 - tree throw
 - gophers
 - worms
 - freeze-thaw
 - small girls

Complex sub-models,
 large-scale variables,
 observations?

With Explicit Numerical Reductionism:
 What if sub model for worm behaviors isn't just right...
 And what about other hillslopes (e.g. dominated by small girls)?

Or:
 empirically based, mathematically rigorous, modeling of hillslopes directly?