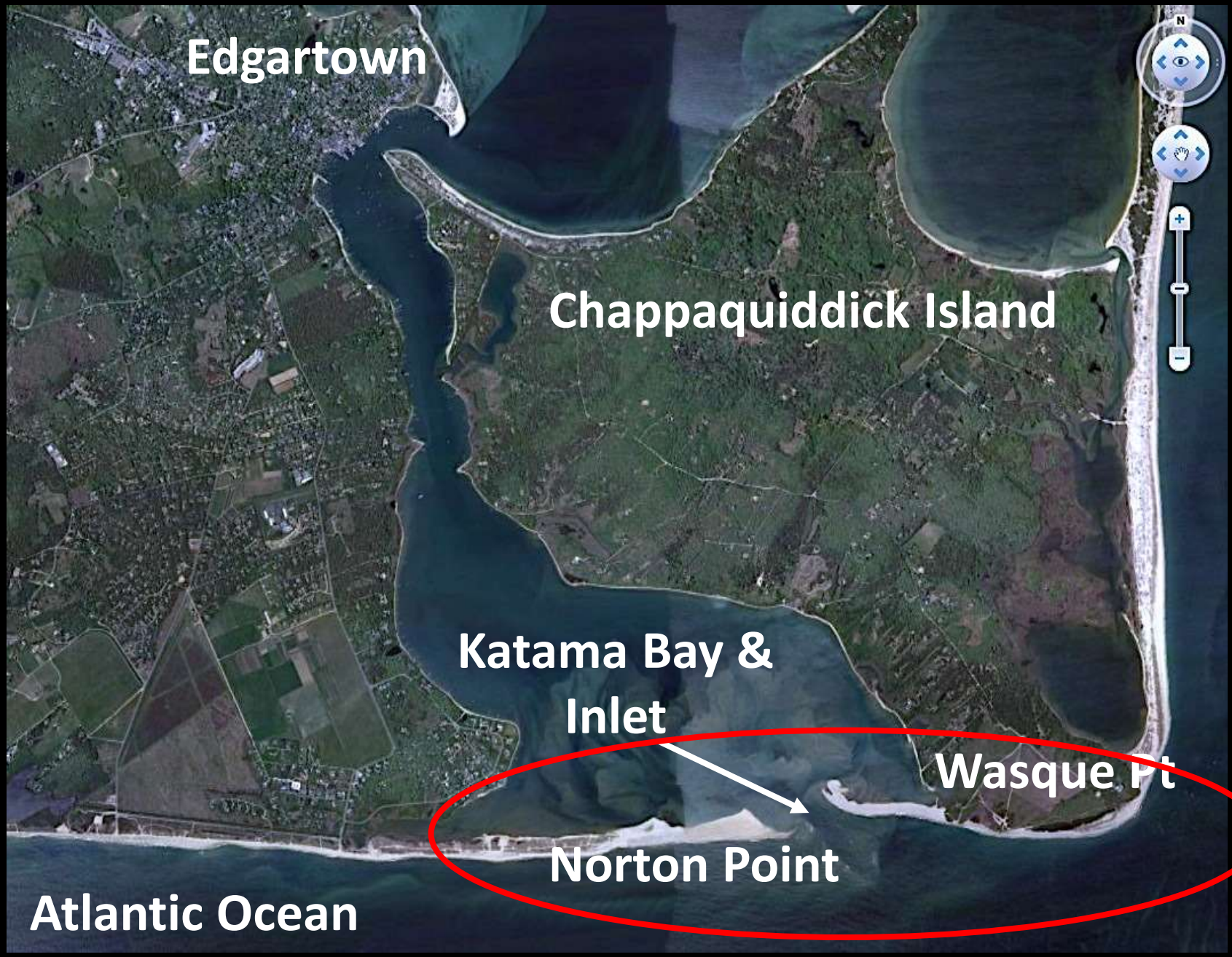

Edgartown
Chappaquiddick Island
Katama Bay &
Inlet
Wasque Pt
Norton Point
Atlantic Ocean


Edgartown
Chappaquiddick Island
Katama Bay &
Inlet
Wasque Pt
Norton Point
Atlantic Ocean

Between 2007 and 2015 Katama Inlet migrated 1.5 km

Between 2007 and 2015 Katama Inlet migrated 1.5 km

Britt Raubenheimer & Julia Hopkins

What moves the sand?

- Waves or currents?
- Daily tidal flows or storms?
  - Hurricanes (~1 day, intense)
  - Nor’easters (few days, less intense)

Bill Brine photo


Martha's Vineyard
Vineyard Sound
Chappaquiddick Is.
Muskeget Channel
> 3 m/s
Atlantic Ocean


Martha's Vineyard
Vineyard Sound
Chappaquiddick Is.
Katama Bay
Katama Inlet
~2 m/s
Muskeget Channel
> 3 m/s
Atlantic Ocean


Martha's Vineyard
Vineyard Sound
Chappaquiddick Is.
Katama Bay
Katama Inlet
~2 m/s
Surfzone
>1 m/s
Muskeget Channel
> 3 m/s
Atlantic Ocean

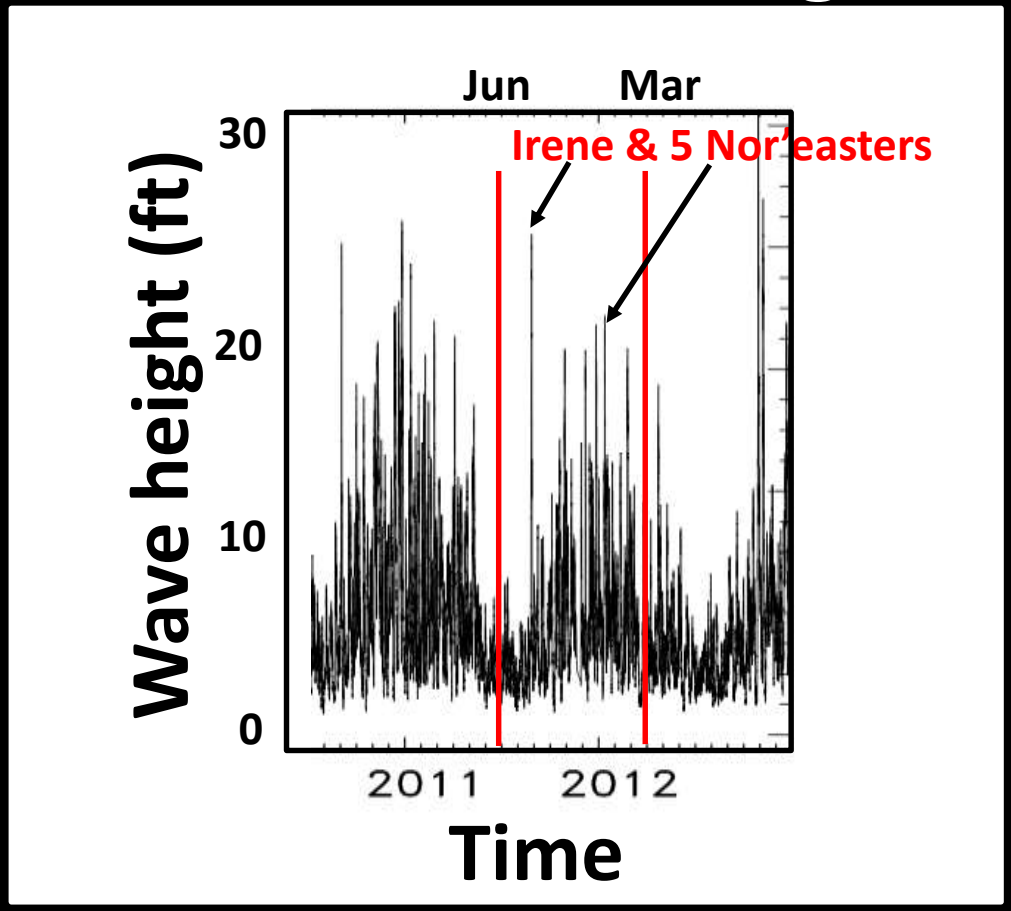

Martha's Vineyard
Vineyard Sound
Chappaquiddick Is.
Katama Bay
Katama Inlet
~2 m/s
Surfzone
>1 m/s
Separation zone
~0 m/s
Muskeget Channel
> 3 m/s
Atlantic Ocean


June 2011
Katama Bay
Chappaquiddick Is.
Norton Point
Atlantic Ocean
Edgartown Rd
Wasque Ave


June 2011
Katama Bay
Norton Point
Edgartown Rd
Plover Ln
Town Cove Rd
Bayview Ave
Waschique Ave
Trustees Ln
Wasque Ave
March 2012
Katama Bay
Edgartown Rd
Plover Ln
Town Cove Rd
Bayview Ave
Waschique Ave
Trustees Ln
Wasque Ave

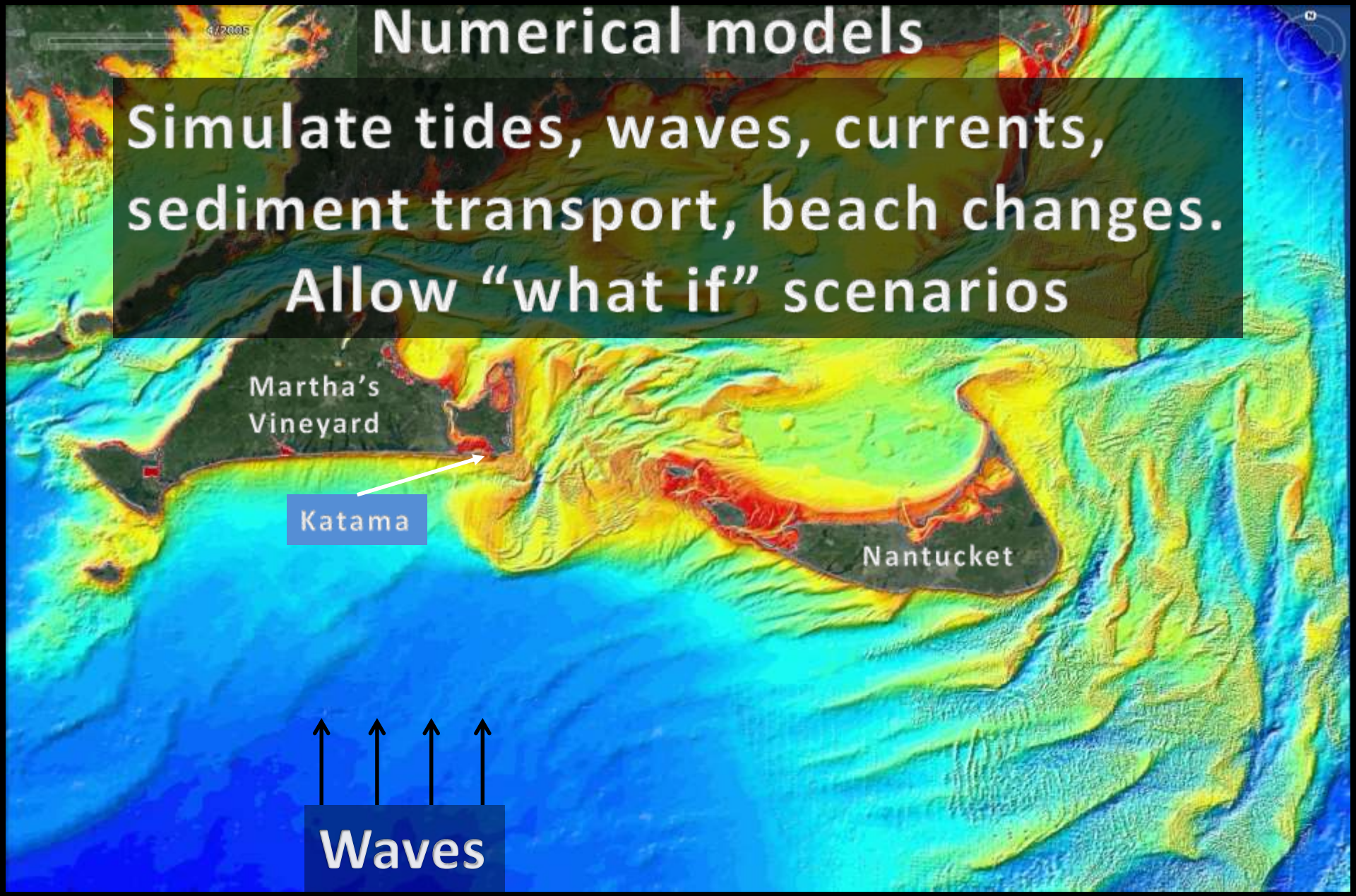

June 2011
Katama Bay
Norton Point
Edgartown Rd
Plover Ln
Town Cove Rd
Bayview Ave
Waschique Ave
Trustees Ln
Wasque Ave
March 2012
500 m

Offshore wave height



What moves the sand?

- Waves or currents?

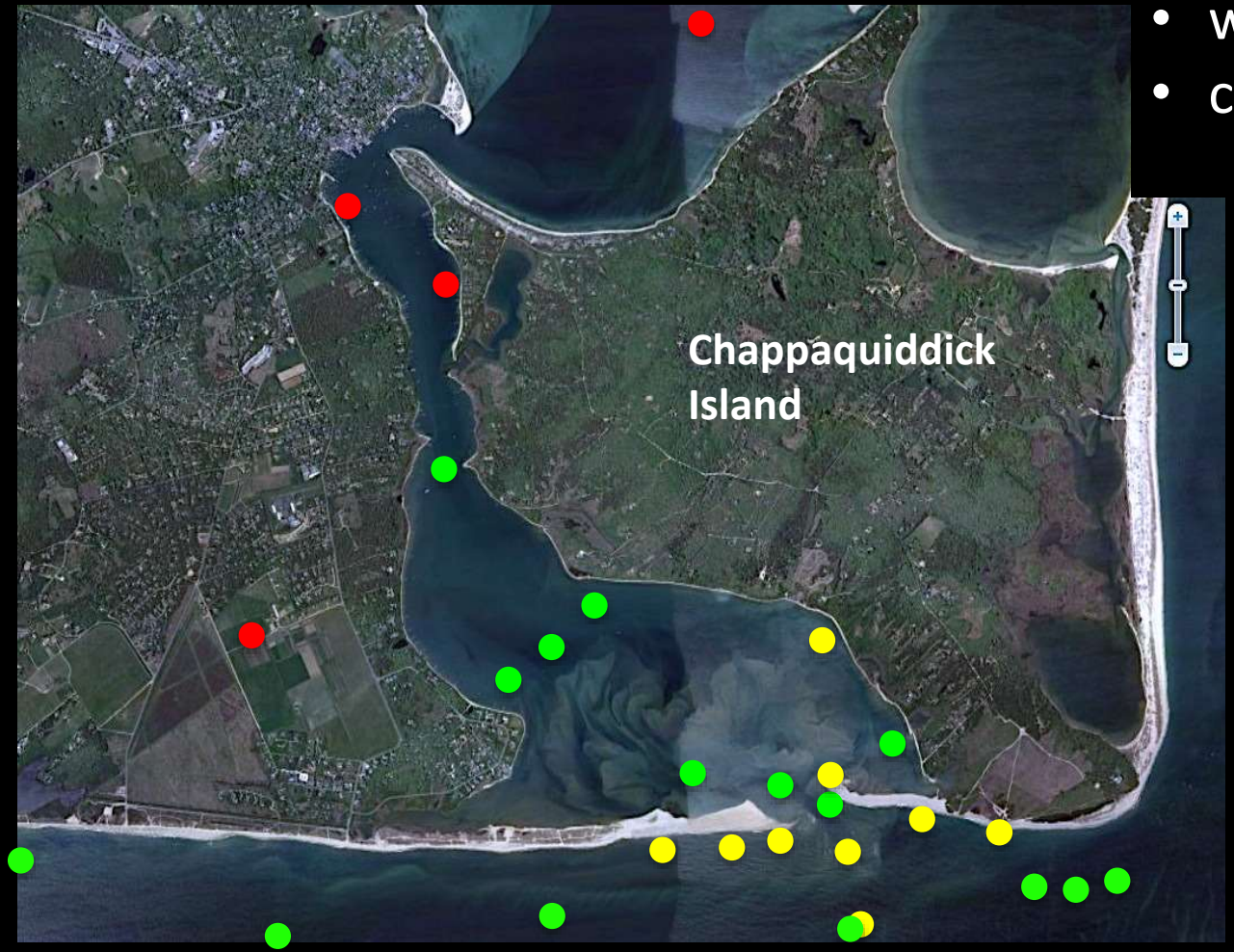

Numerical models
Simulate tides, waves, currents, sediment transport, beach changes.
Allow "what if" scenarios
Martha's Vineyard
Katama
Nantucket
Waves

Be skeptical of models!

Be skeptical of models!

Test them *at your location*

- sea level (tides, surge)
- waves
- currents



- Pressure
- Pressure & Profiler
- Pressure & Current Meter

Test the model

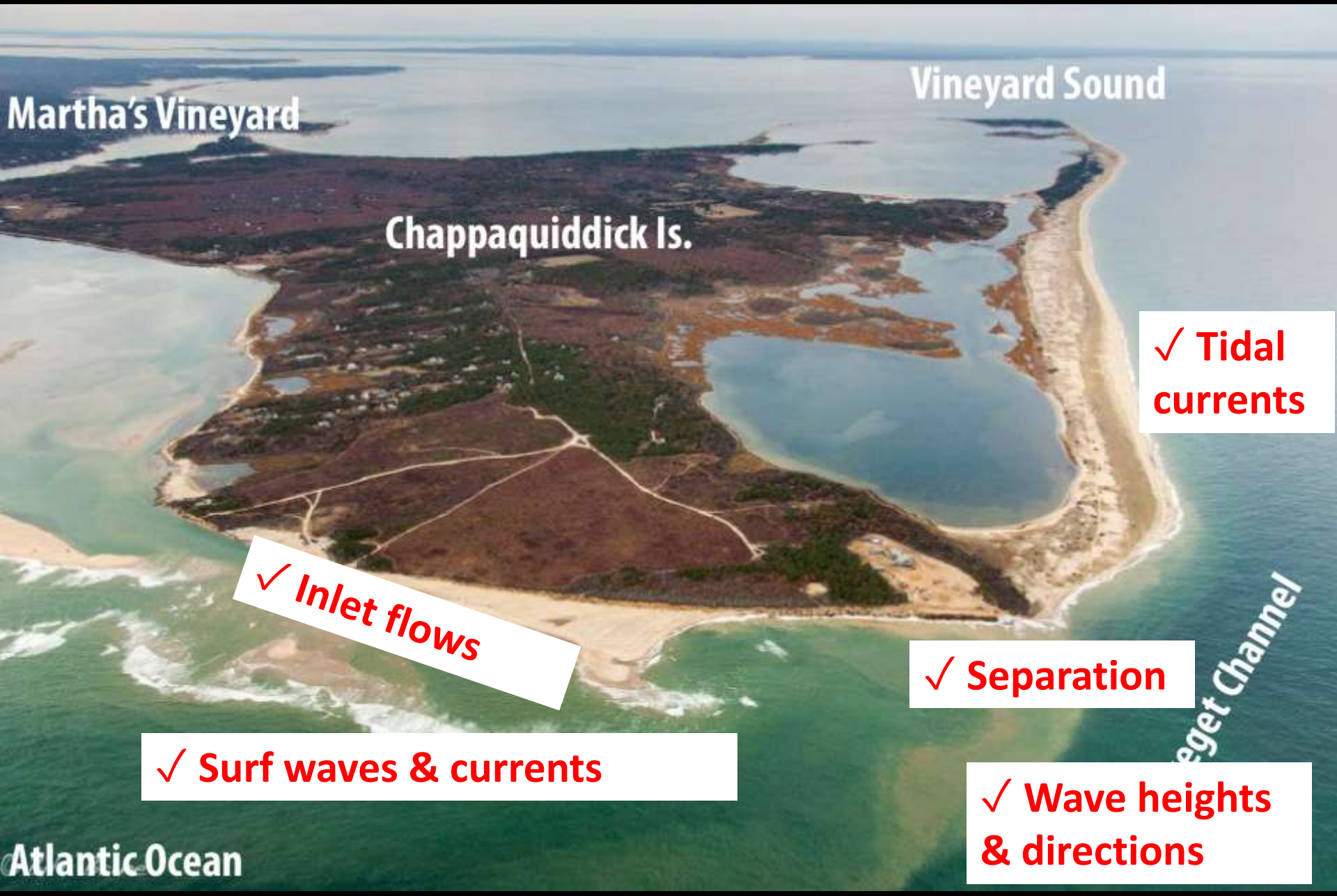
Bill Brine photo

Bill Brine photo

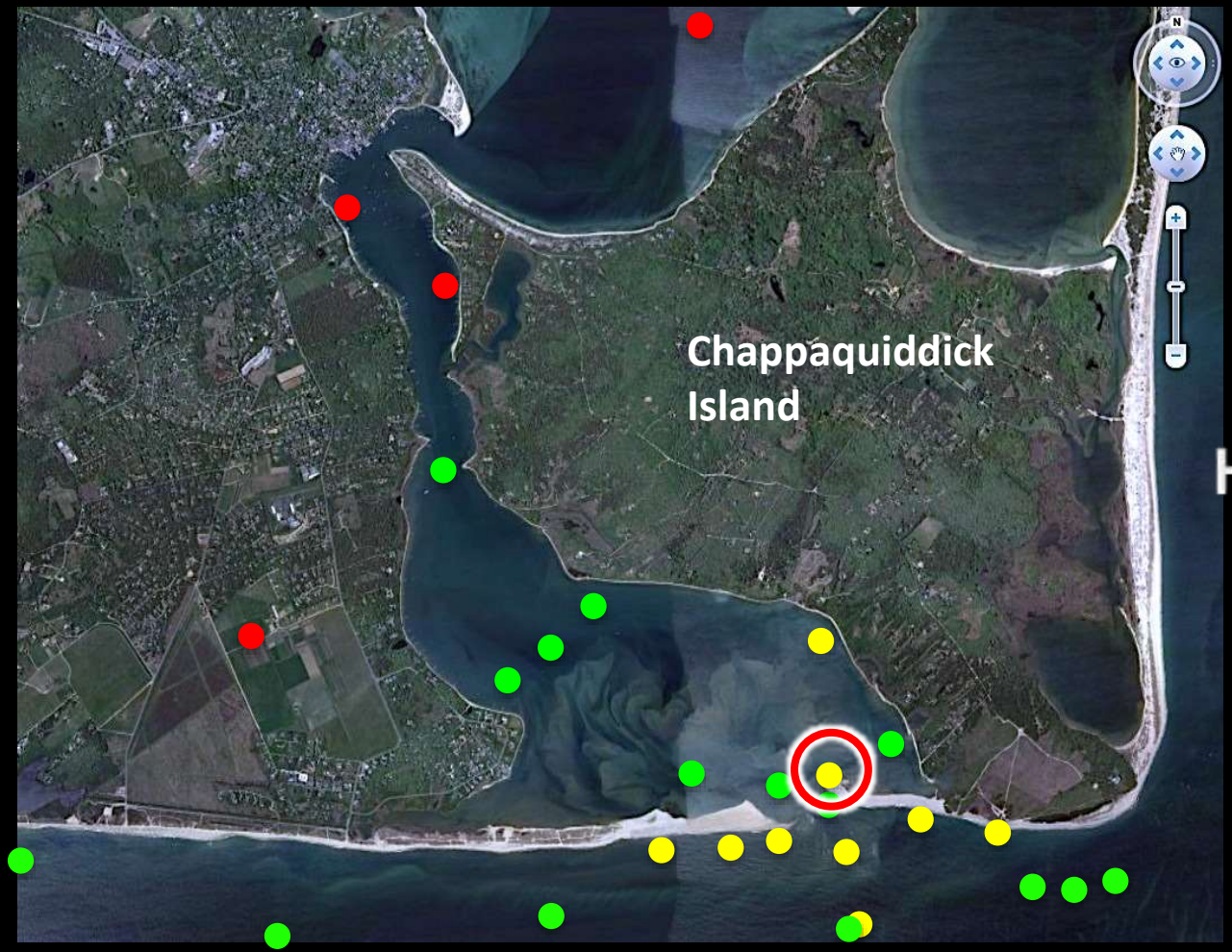
Bill Brine photo

Bill Brine photo

Bill Brine photo

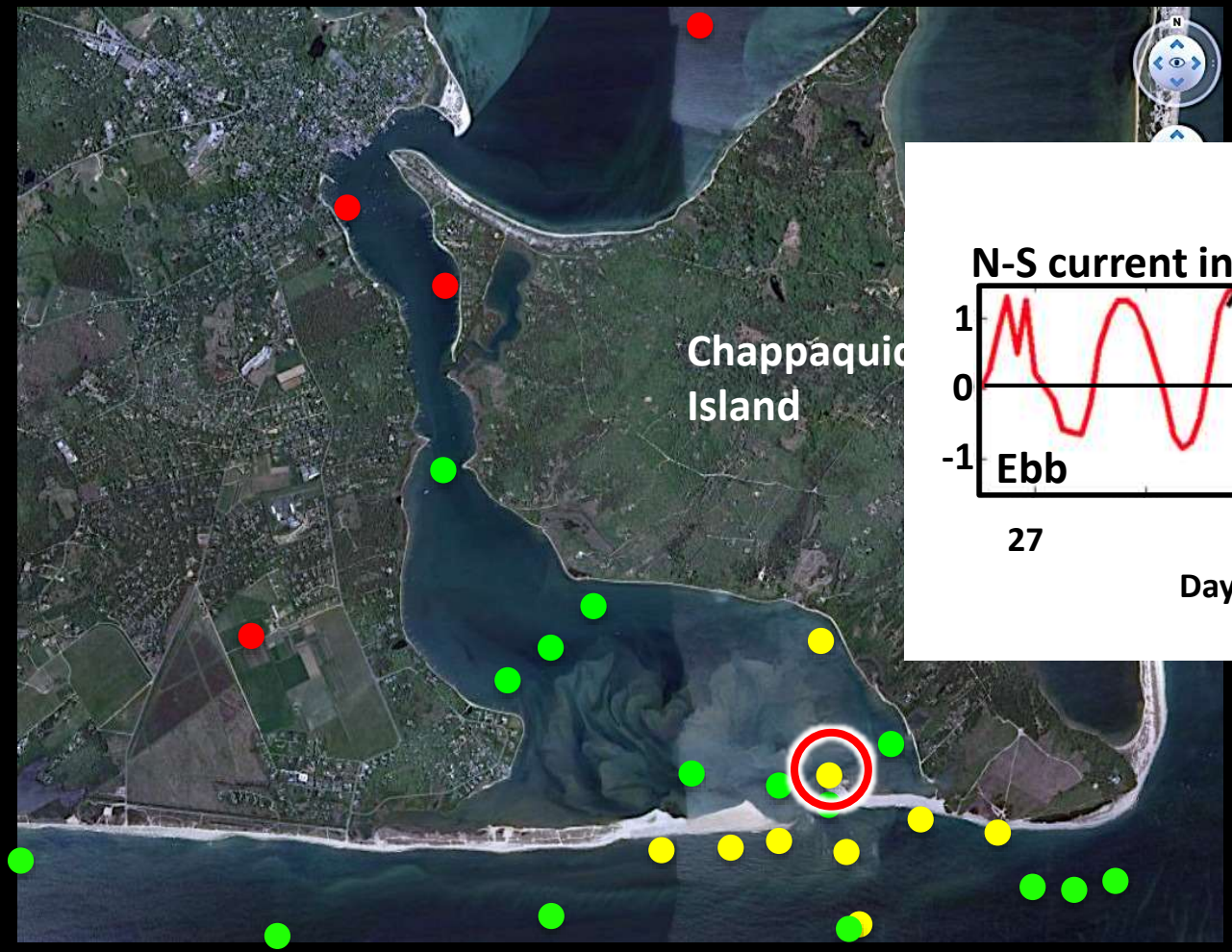


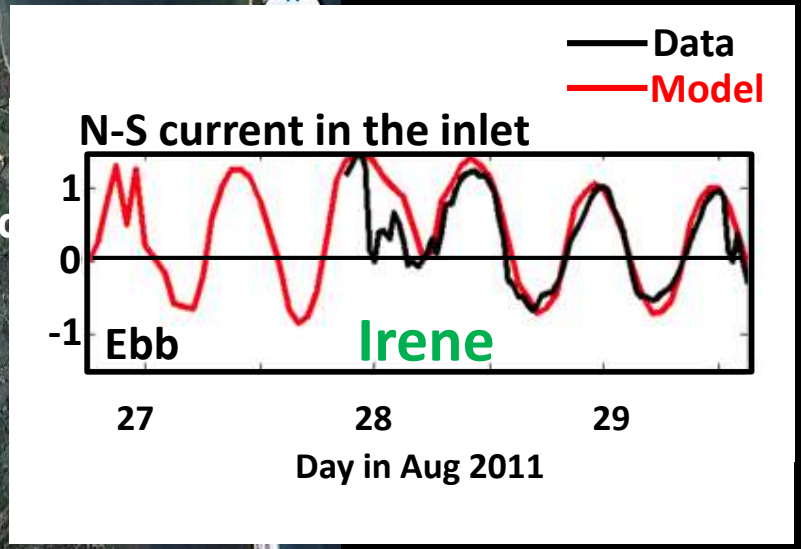
Bill Brine photo



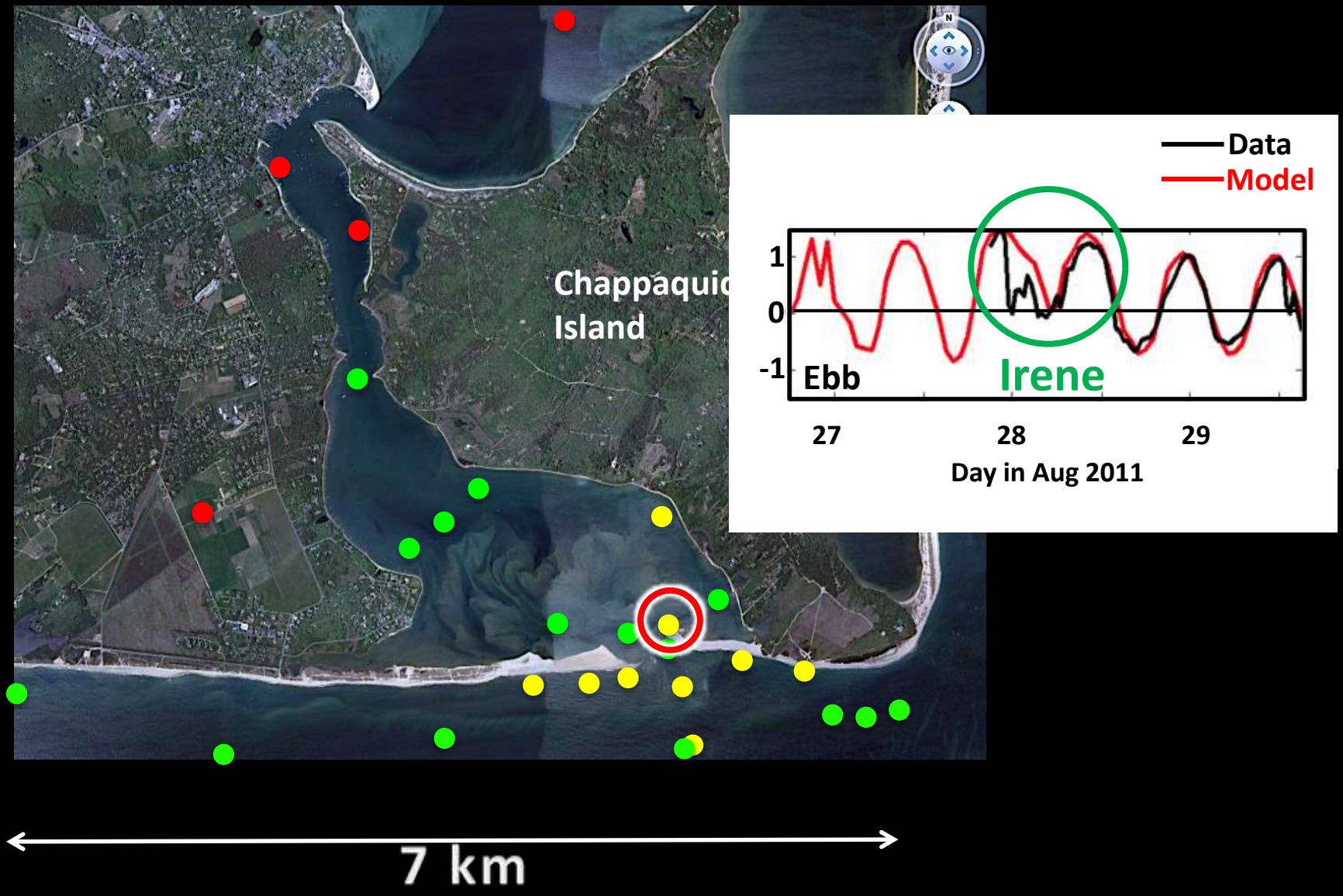
Hurricane Irene

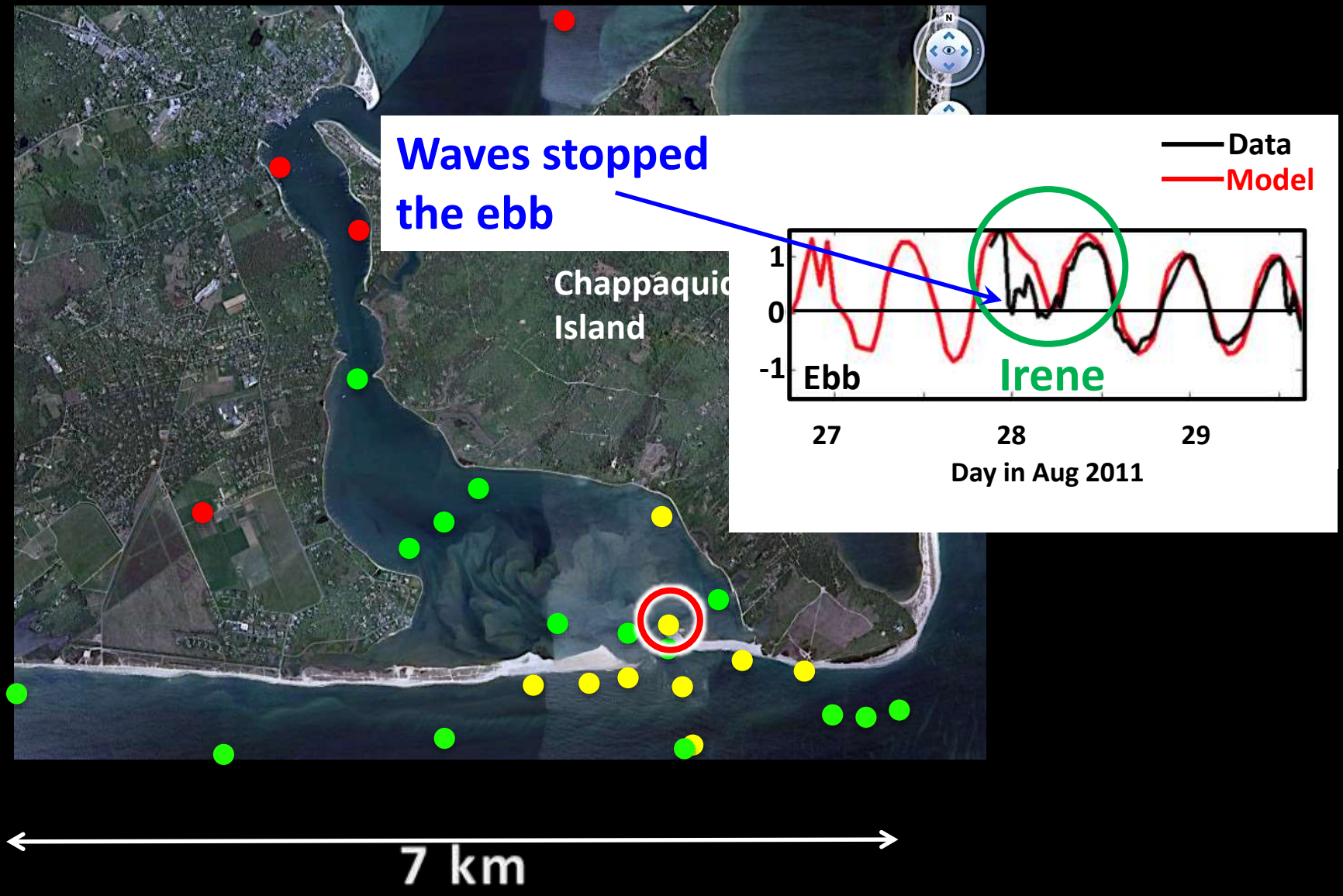
7 km


Chappaquid
Island


Data
Model
N-S current in the inlet
1
0
-1
Ebb
Irene
27
28
29
Day in Aug 2011

7 km


Chappaquid
Island
Data
Model
1
0
-1
Ebb
Irene
27
28
29
Day in Aug 2011
7 km


Waves stopped the ebb
Chappaquiddick Island
Data
Model
1
0
-1
Ebb
Irene
27
28
29
Day in Aug 2011
7 km

Simulated tides, waves, and currents are accurate.

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Sand is harder to simulate. Is the model accurate?

Simulated tides, waves, and currents are accurate.

Sand is harder to simulate. Is the model accurate?

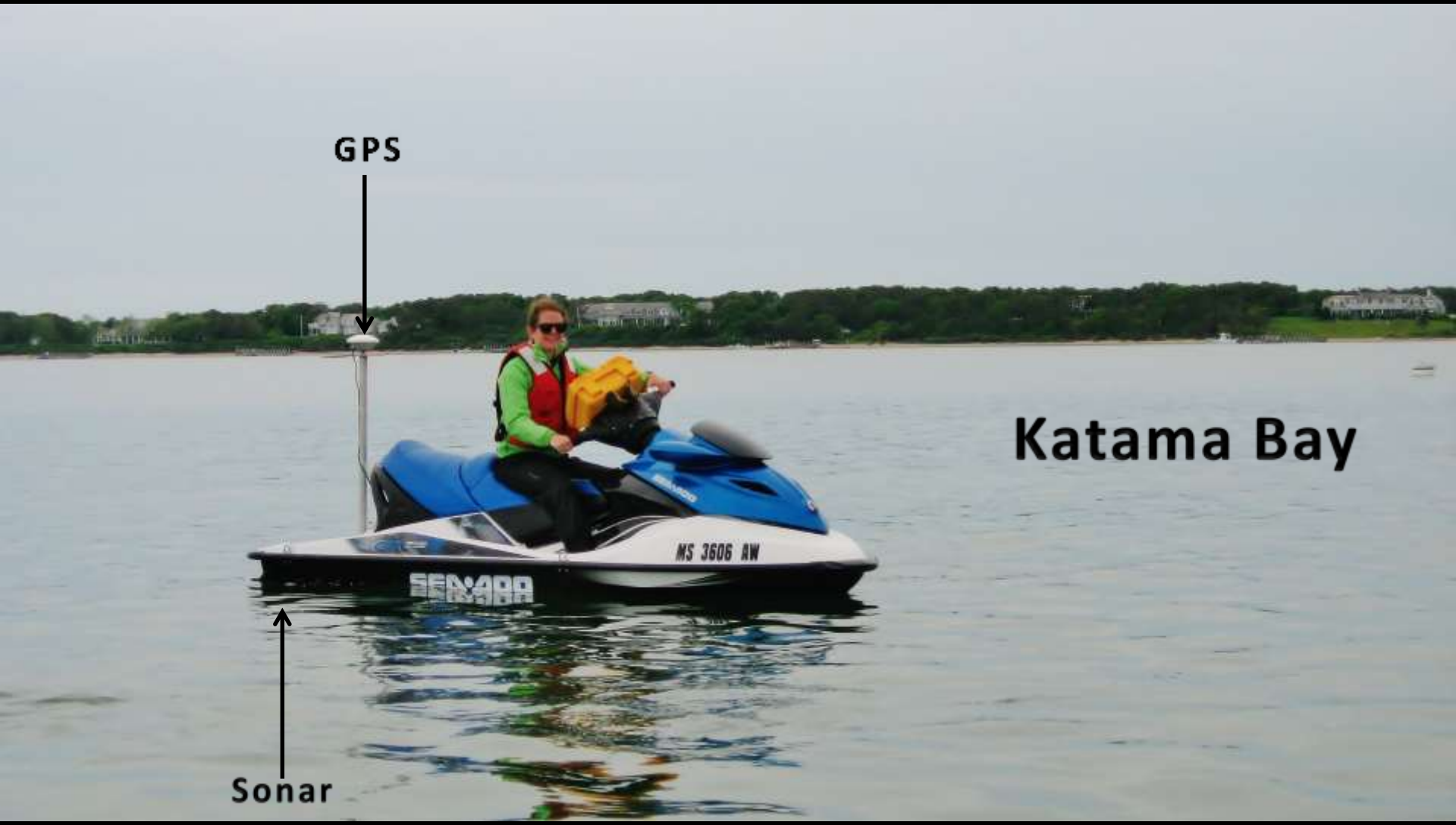
Survey the bathymetry before and after Irene & Sandy.

Simulated tides, waves, and currents are accurate.

Sand is harder to simulate. Is the model accurate?

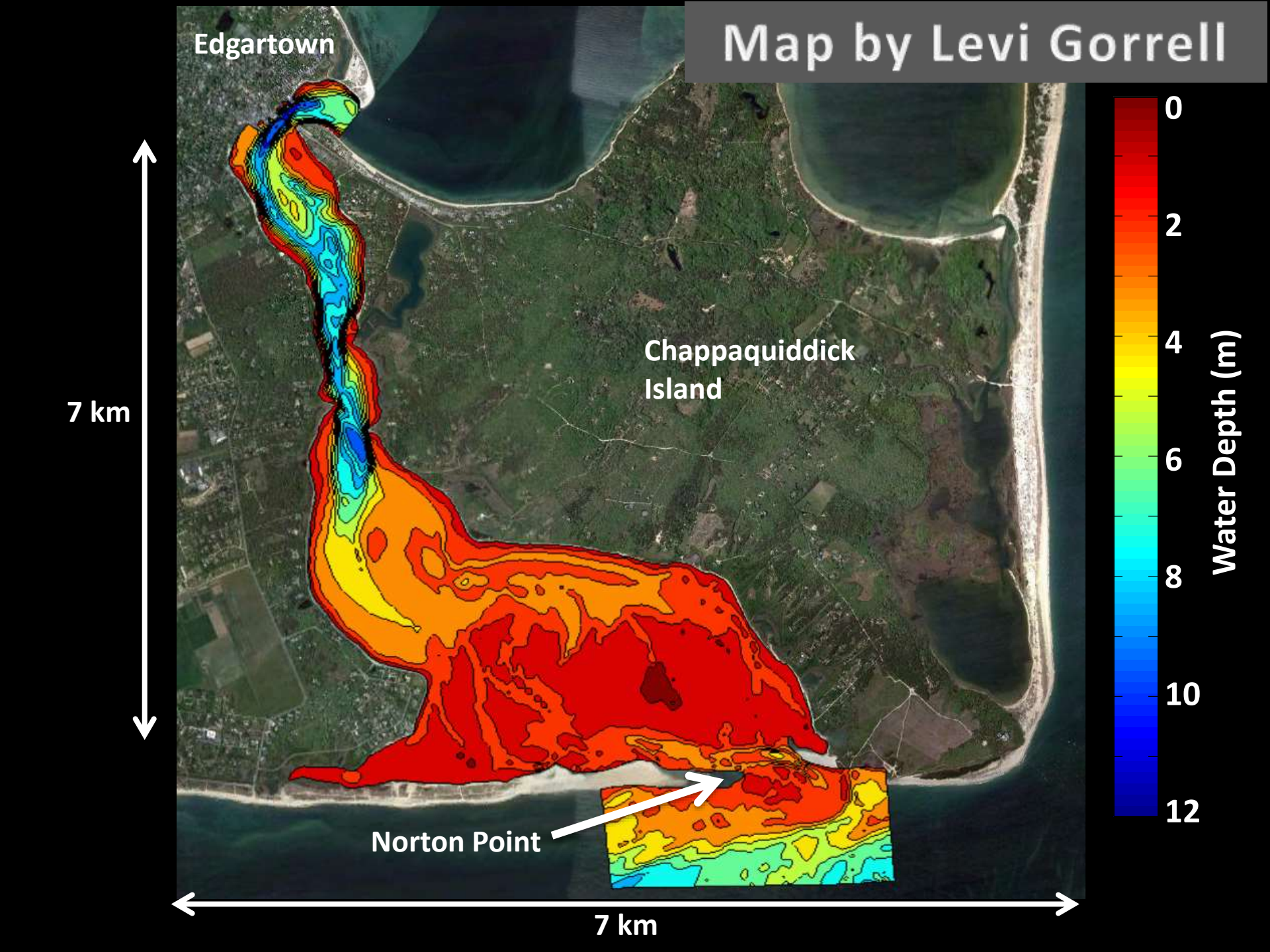
Survey the bathymetry before and after Irene & Sandy.

Compare simulations with observations.

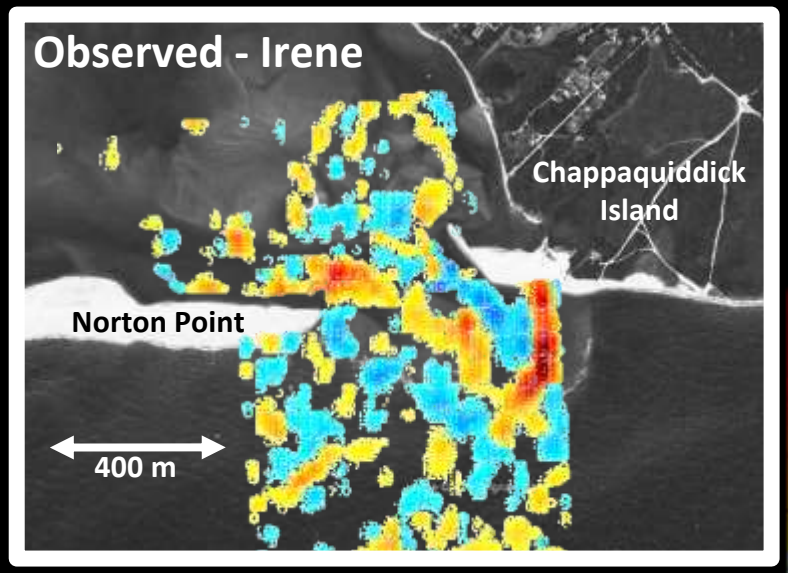


Maddie Smith

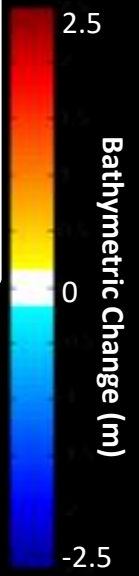
Jeff Hansen


Map by Levi Gorrell
Edgartown
Chappaquiddick Island
Norton Point
7 km
7 km
Water Depth (m)
0
2
4
6
8
10
12

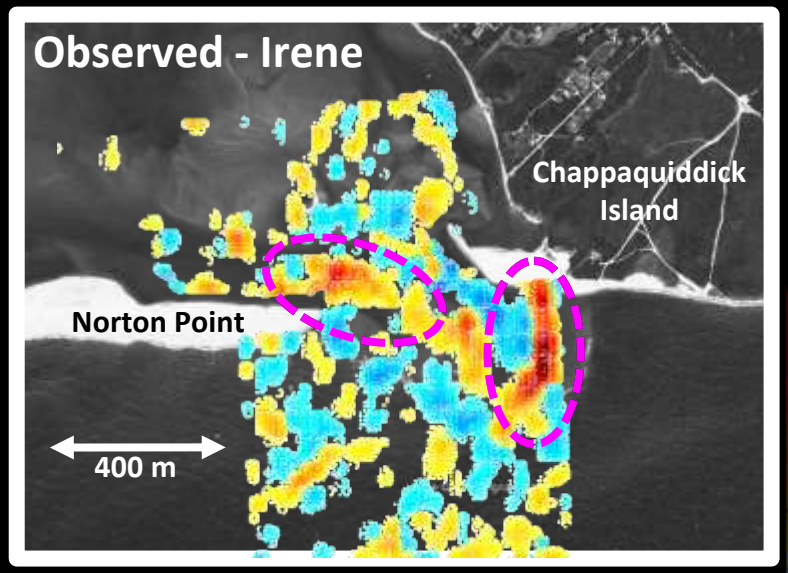
Irene Morphological Change



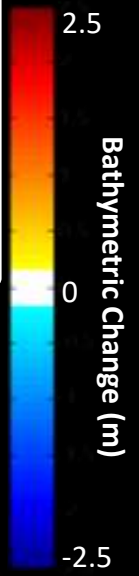
Observed



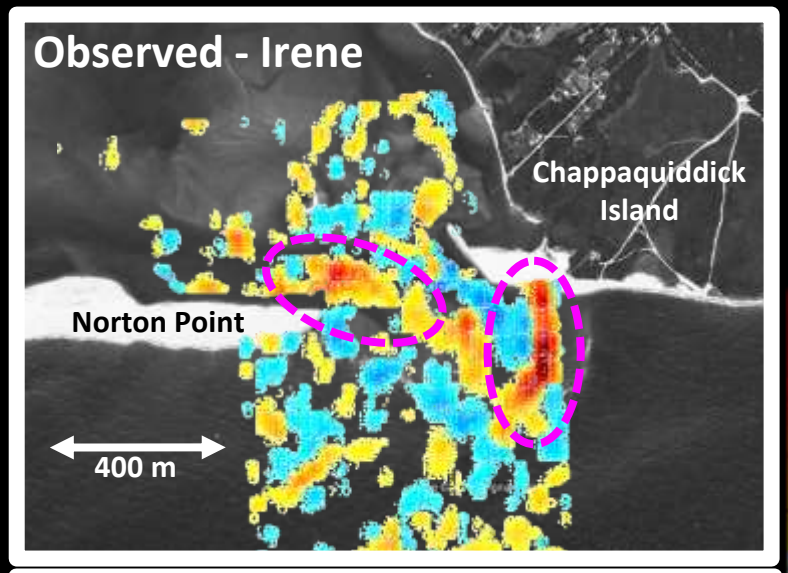
Irene Morphological Change



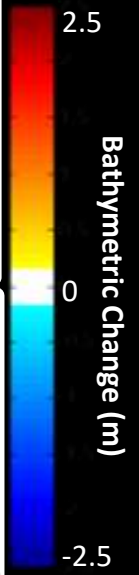
Observed

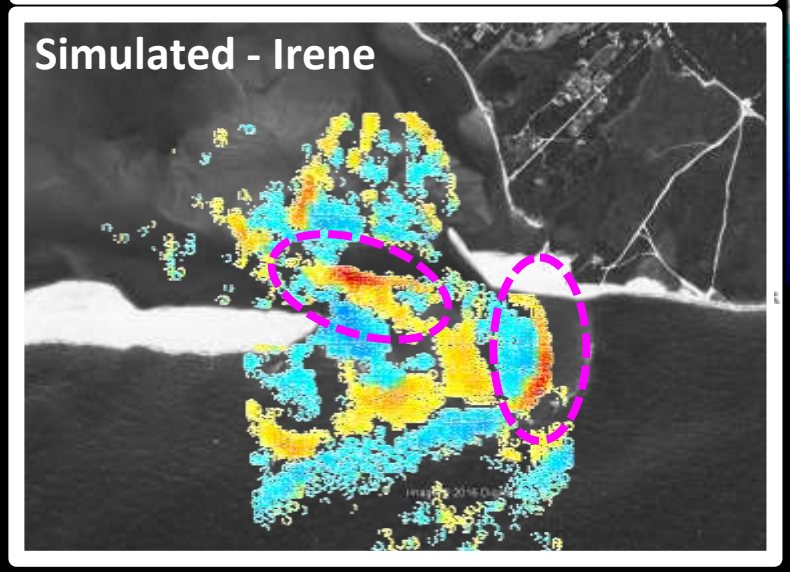


Simulations: Irene



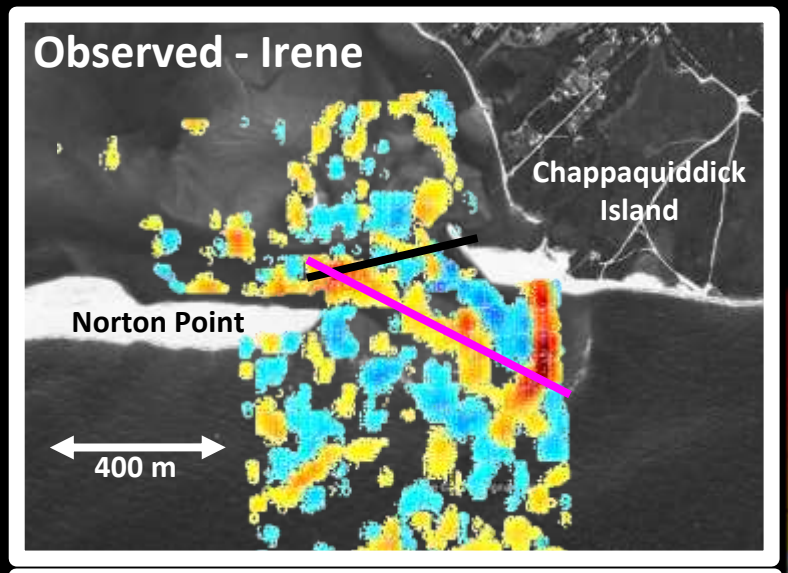
Observed



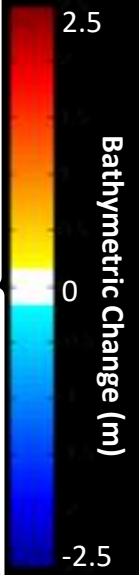


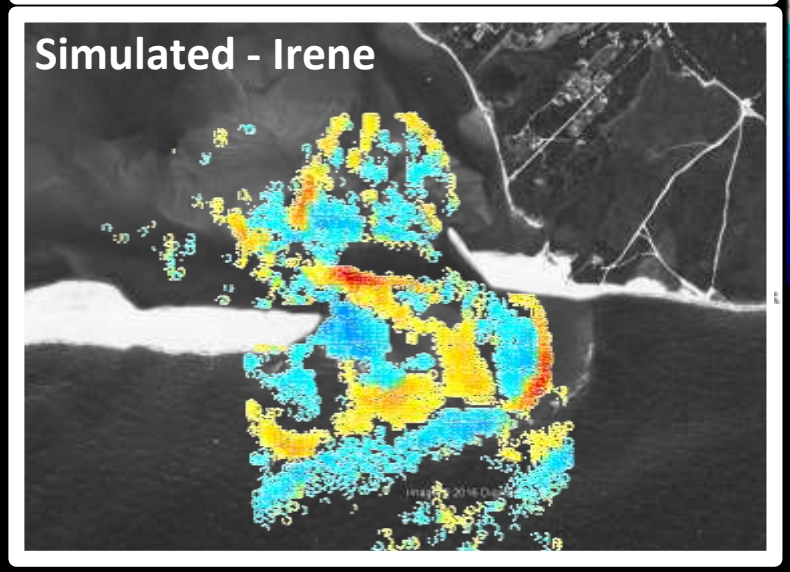
Simulated

Simulations: Irene



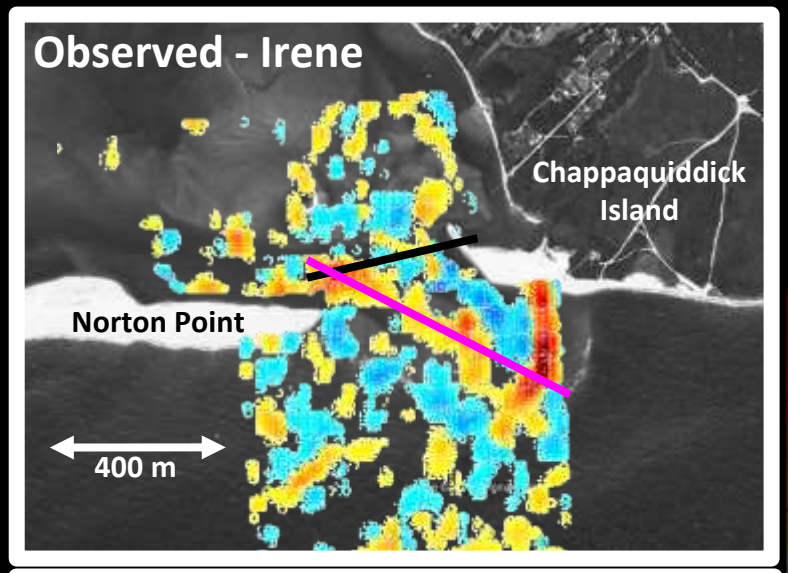
Observed

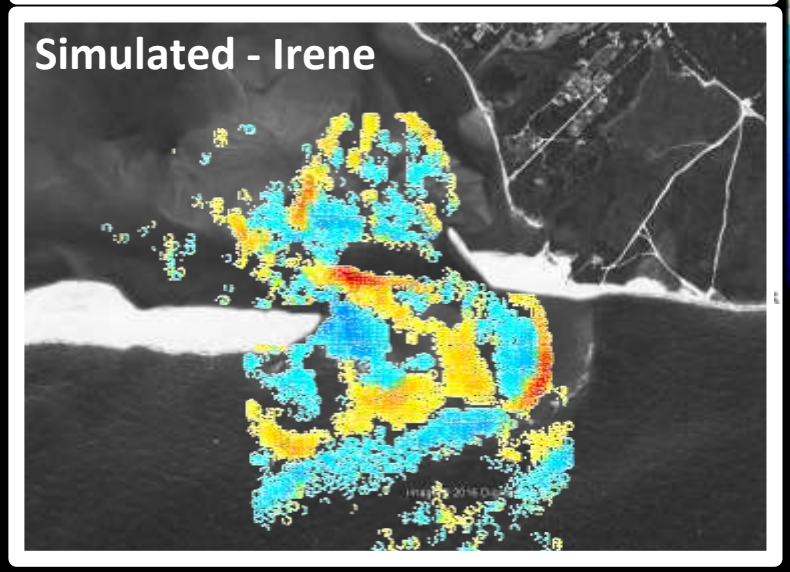




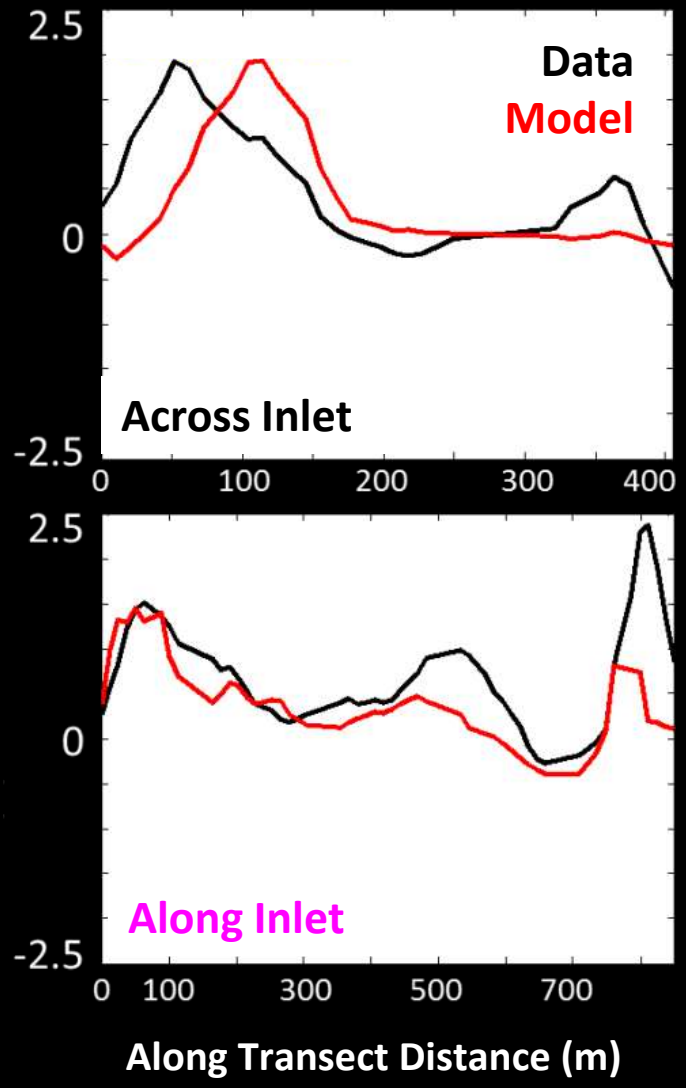
Simulated

Simulations: Irene





Bathymetric Change (m)



The model has skill simulating

- **Tides**
- **Waves**
- **Currents**
- **Morphological evolution**

Use it for “what if” scenarios

The model has skill simulating

- **Tides**
- **Waves**
- **Currents**
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Use it for “what if” scenarios

Waves or currents?

Katama is a “mixed wave- & current-driven transport” system

- Waves can be big

Katama is a “mixed wave- & current-driven transport” system

- Waves can be big
- Tidal currents are strong

Katama is a “mixed wave- & current-driven transport” system

- Waves can be big
- Tidal currents are strong
- Currents decreased as inlet evolved

Tidal-current transport bigger than wave transport

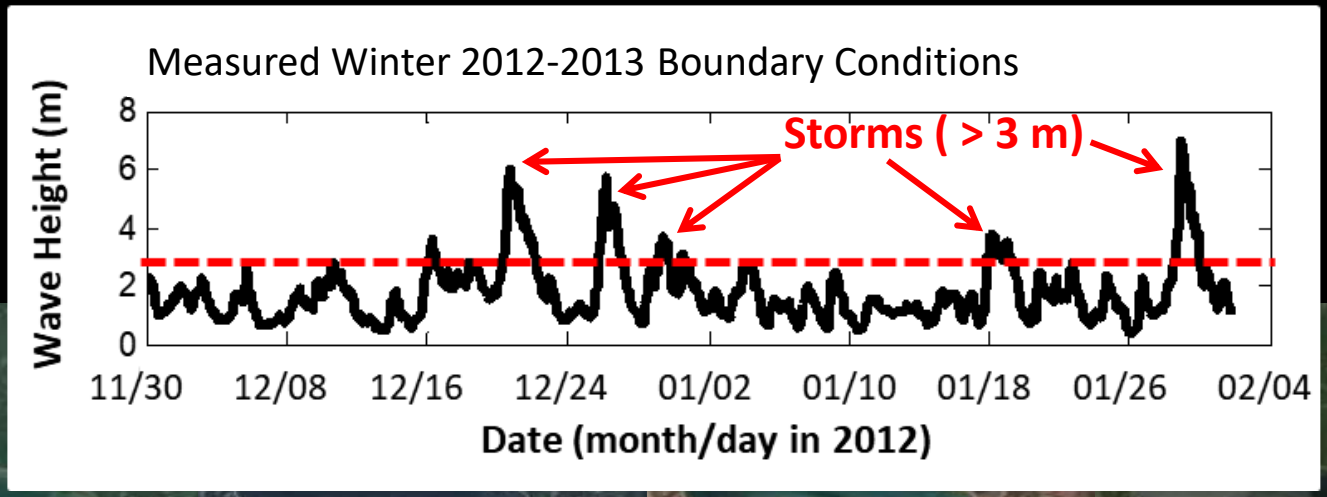
W/C = 0.6 | W/C = 1.0 | W/C = 1.0 | W/C = 1.6

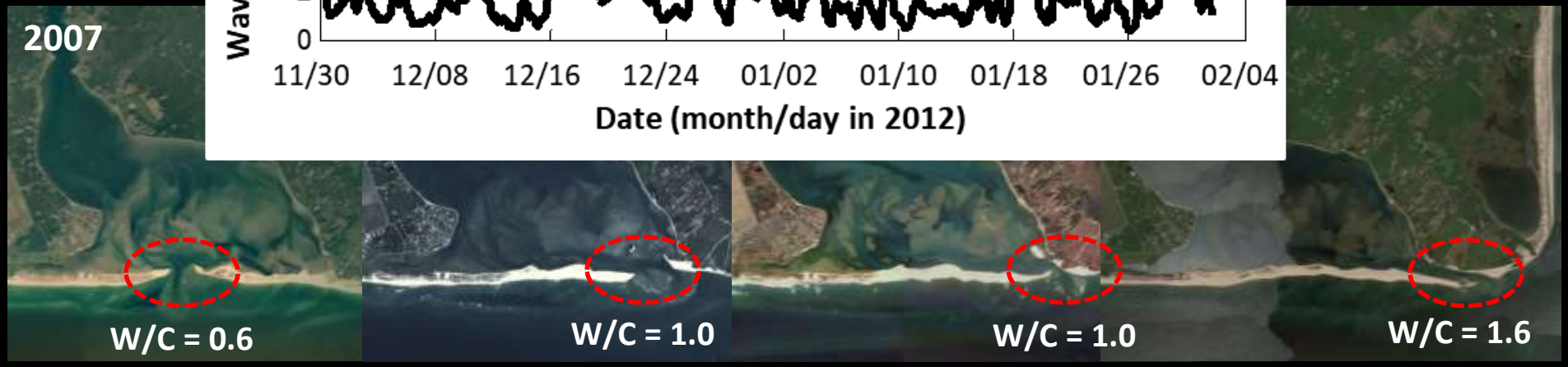
2 m/s

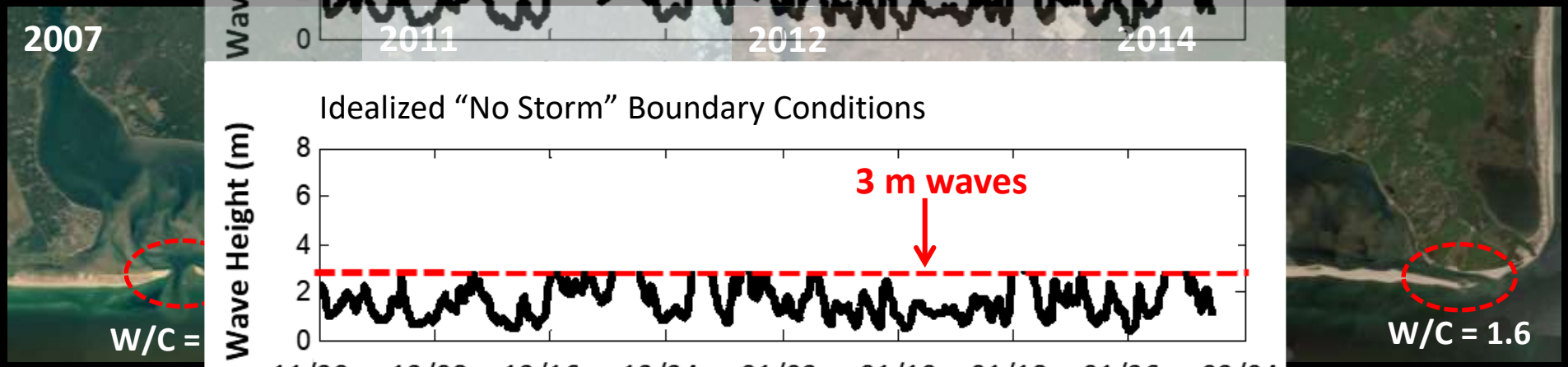
0.5 m/s

Tidal-current transport bigger than wave transport

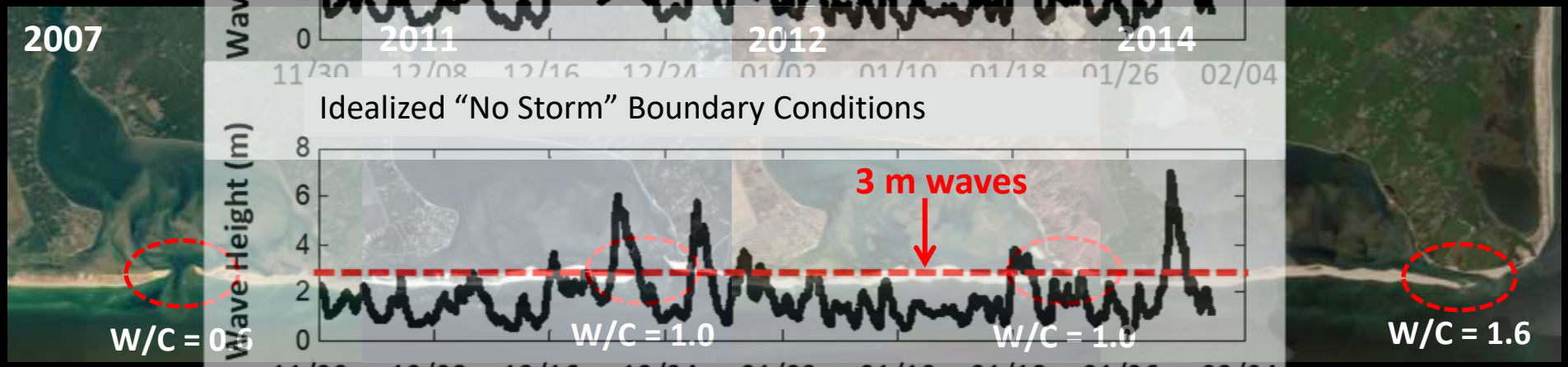
Wave-driven transport bigger than tidal transport


Measured Winter 2012-2013 Boundary Conditions
Wave Height (m)
8
6
4
2
0
Storms (> 3 m)
11/30
12/08
12/16
12/24
01/02
01/10
01/18
01/26
02/04
Date (month/day in 2012)

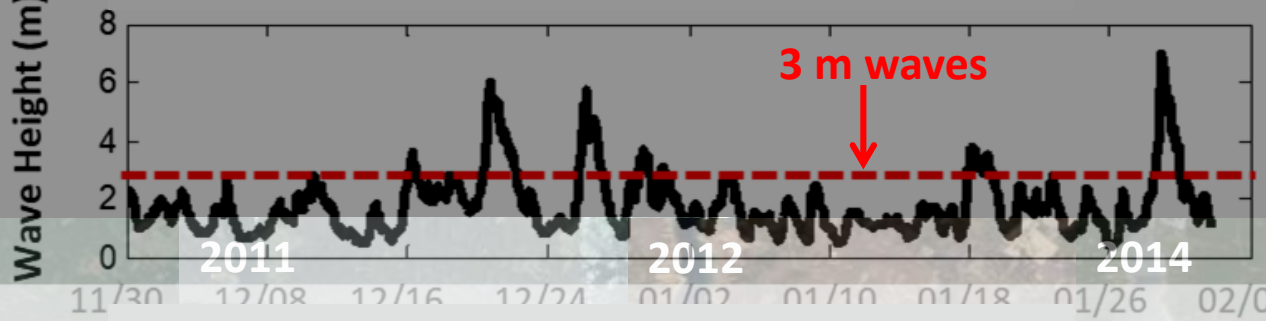

2007
W/C = 0.6
W/C = 1.0
W/C = 1.0
W/C = 1.6


2007
2011
2012
2014
W/C =
W/C = 1.6

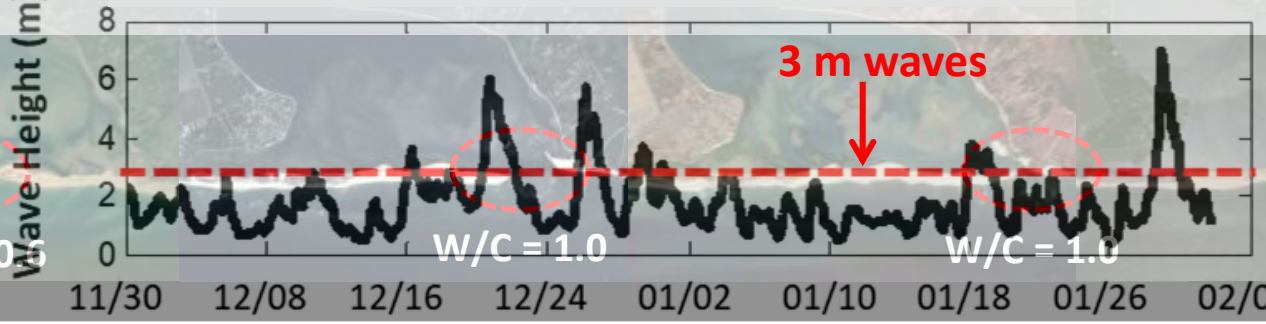
Measured Winter 2012-2013 Boundary Conditions
Wave Height (m)
8
6
4
2
0
Idealized “No Storm” Boundary Conditions
3 m waves
11/30
12/08
12/16
12/24
01/02
01/10
01/18
01/26
02/04
Date (month/day in 2012)



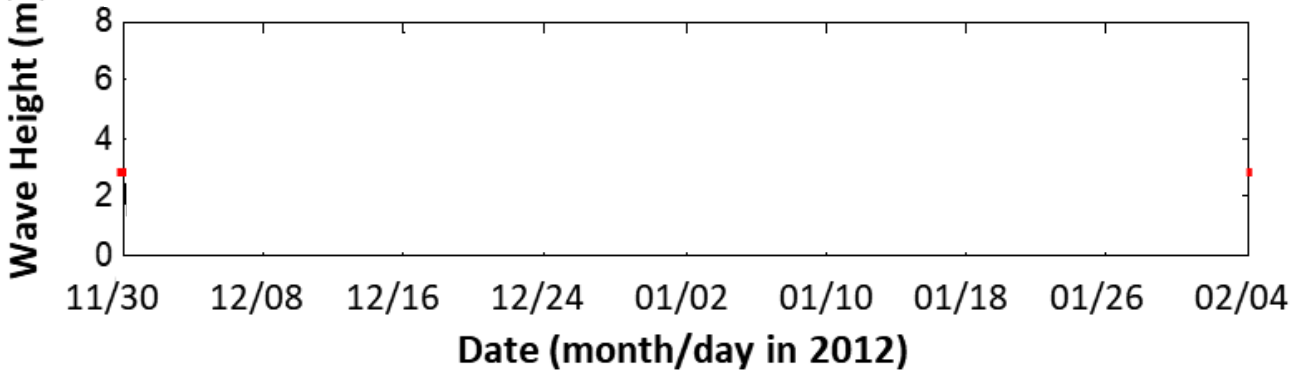
Measured Winter 2012-2013 Boundary Conditions



Idealized "No Storm" Boundary Conditions



Idealized "No Waves" Boundary Conditions



Tidal-current transport bigger than wave transport

Wave-driven transport bigger than tidal transport

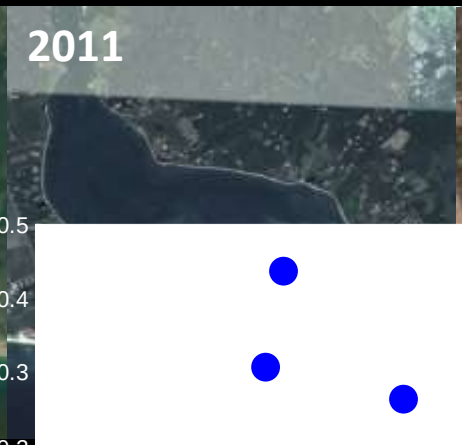
2 m/s

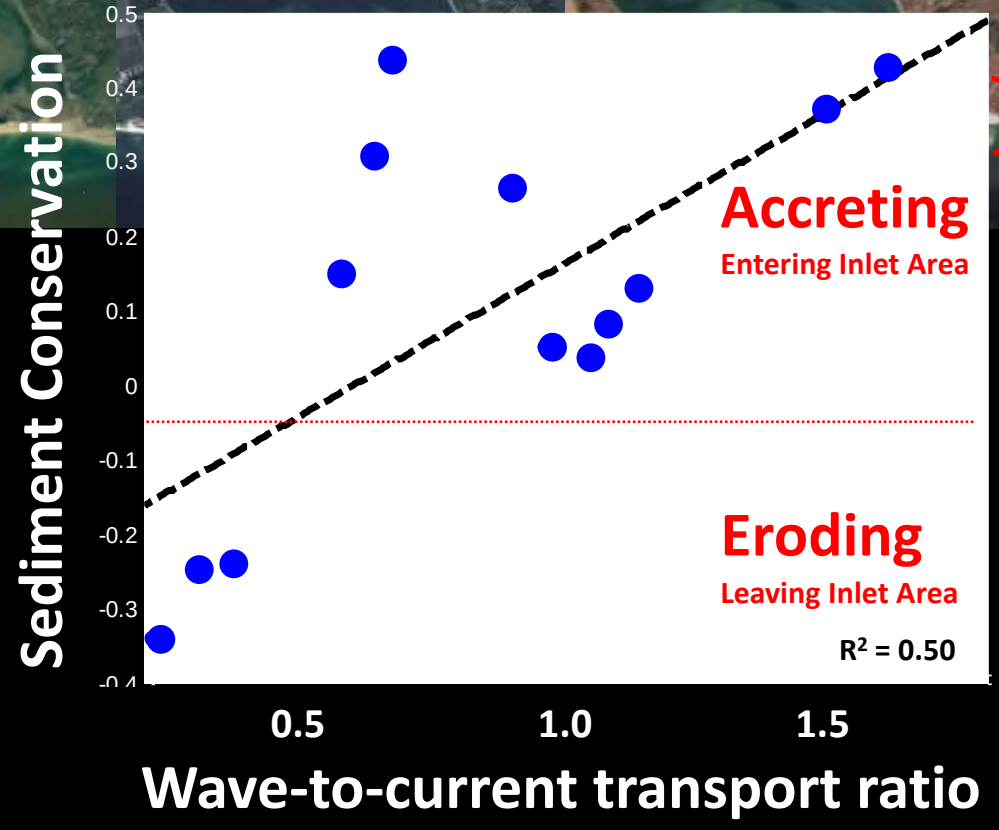
0.5 m/s

Currents > Waves → Waves > Currents

W/C = 0.6

W/C = 1.6





Currents > Waves

Waves > Currents

After breaching, waves deposit sediment

After breaching, waves deposit sediment

less scour

- **Lengthens, narrows, and shoals**

After breaching, waves deposit sediment

less scour

- **Lengthens, narrows, and shoals**

increased friction

- **Tidal currents decrease**

After breaching, waves deposit sediment

less scour

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- **Waves deposit sediment**

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After breaching, waves deposit sediment

- **Lengthens, narrows, and shoals**
- **Tidal currents decrease**
- **Waves deposit sediment**
- **Lengthens, narrows, and shoals**

less scour

increased friction

Feedback, evolution accelerates

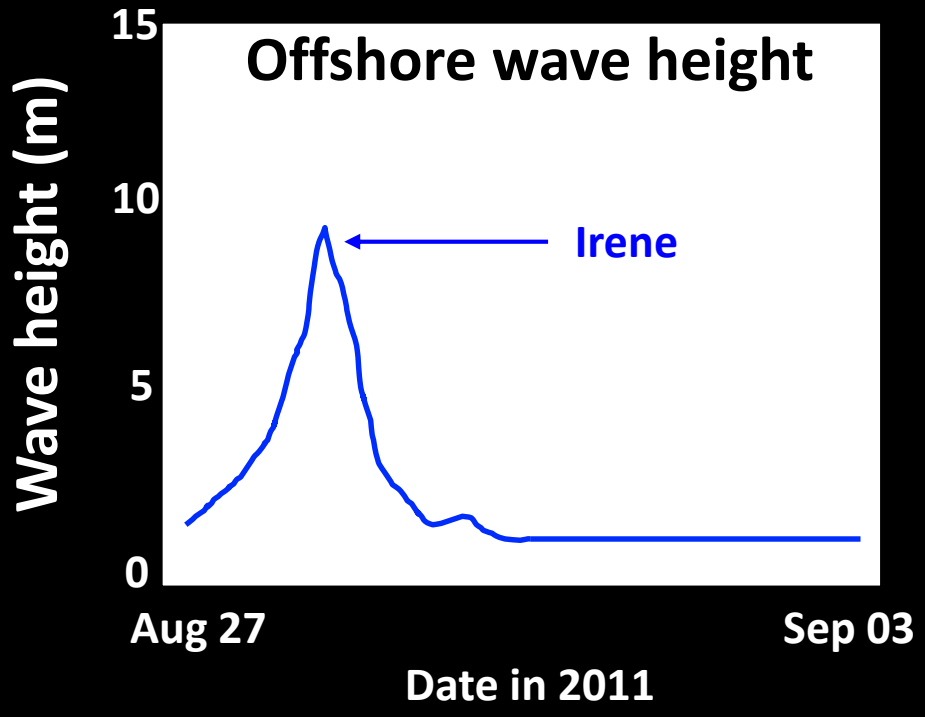
Waves move sand

Hurricanes (high energy, short duration)

Nor’easters (energetic for a few days)

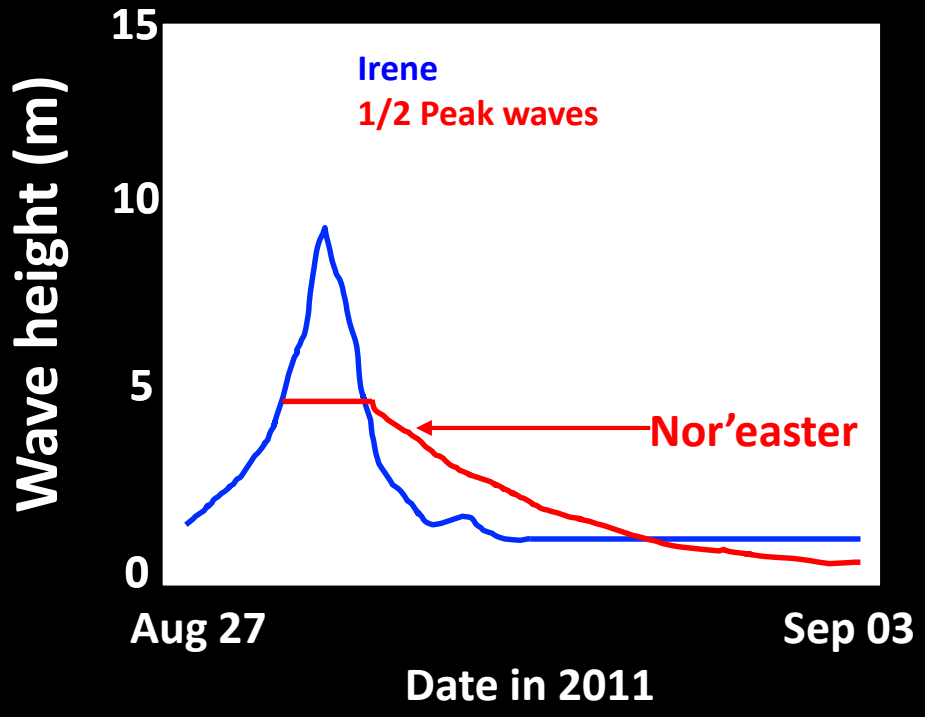
Which moves more sand?

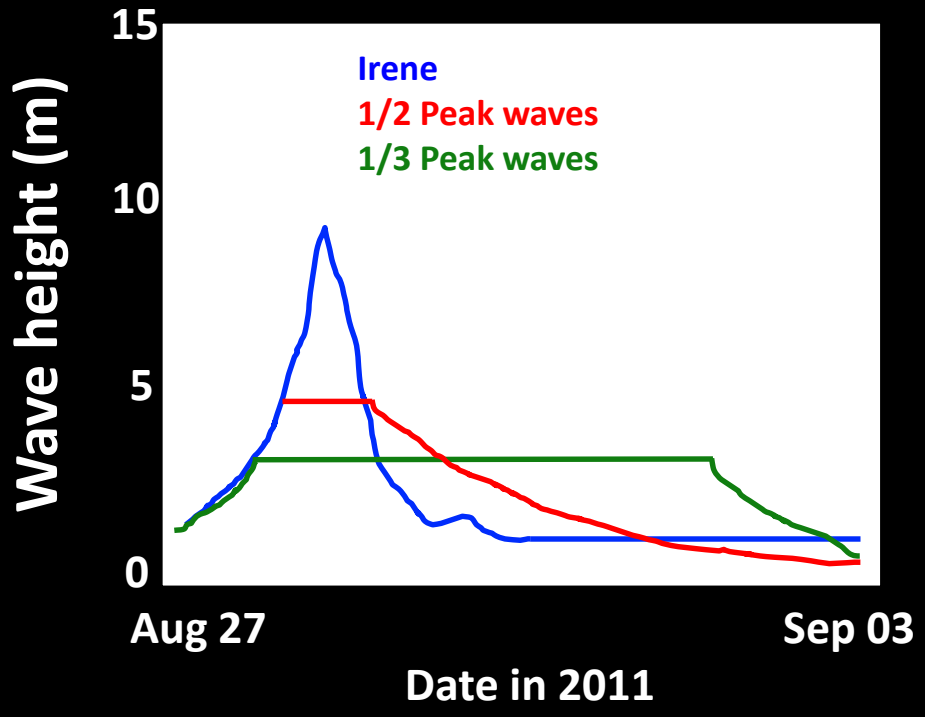
Hurricane Irene:
Rapid rise to ~9 m waves
Rapid decline

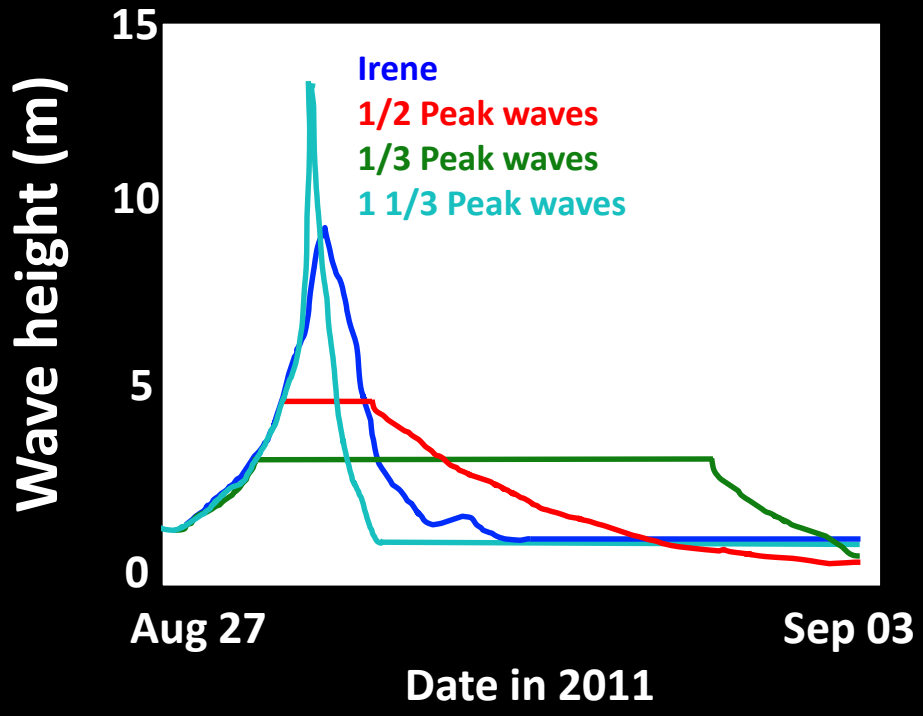


Hurricane Irene:
Rapid rise to ~9 m waves
Rapid decline

Nor'easter:
Rapid rise to ~5 m waves
Slow decline

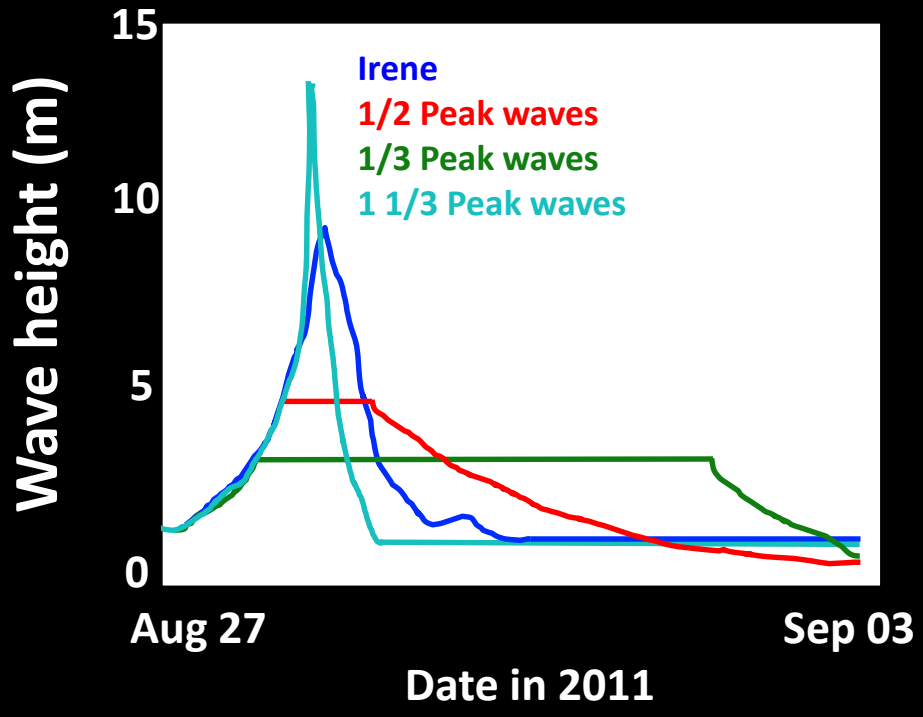



Irene
1/2 Peak waves
1/3 Peak waves
Wave height (m)
15
10
5
0
Aug 27
Sep 03
Date in 2011

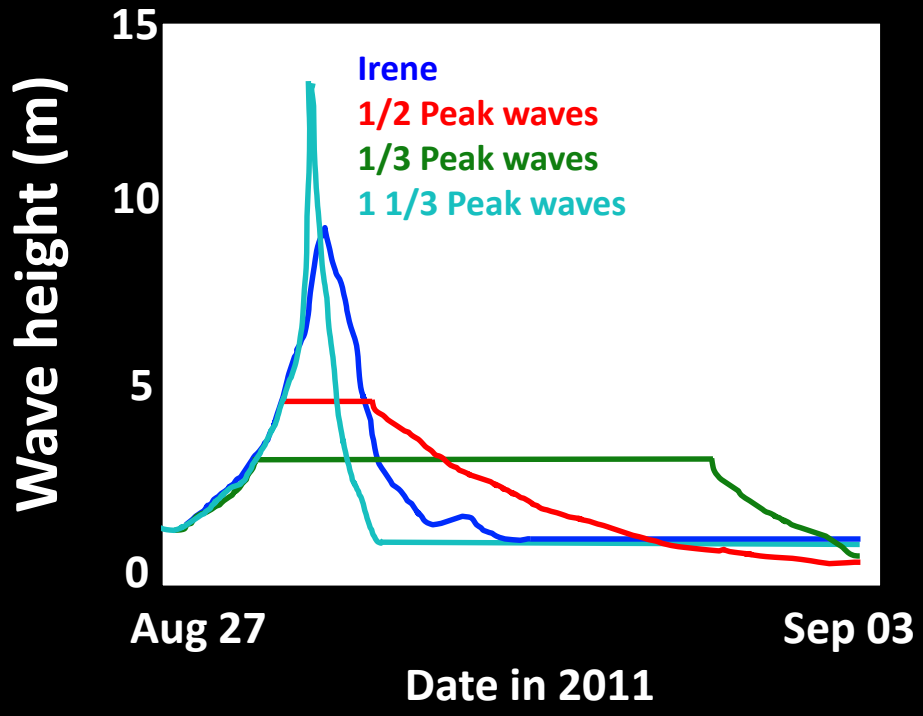

Wave height (m)
15
10
5
0
Irene
1/2 Peak waves
1/3 Peak waves
1 1/3 Peak waves
Aug 27
Sep 03
Date in 2011

Storm *Intensity* = peak energy / duration of peak

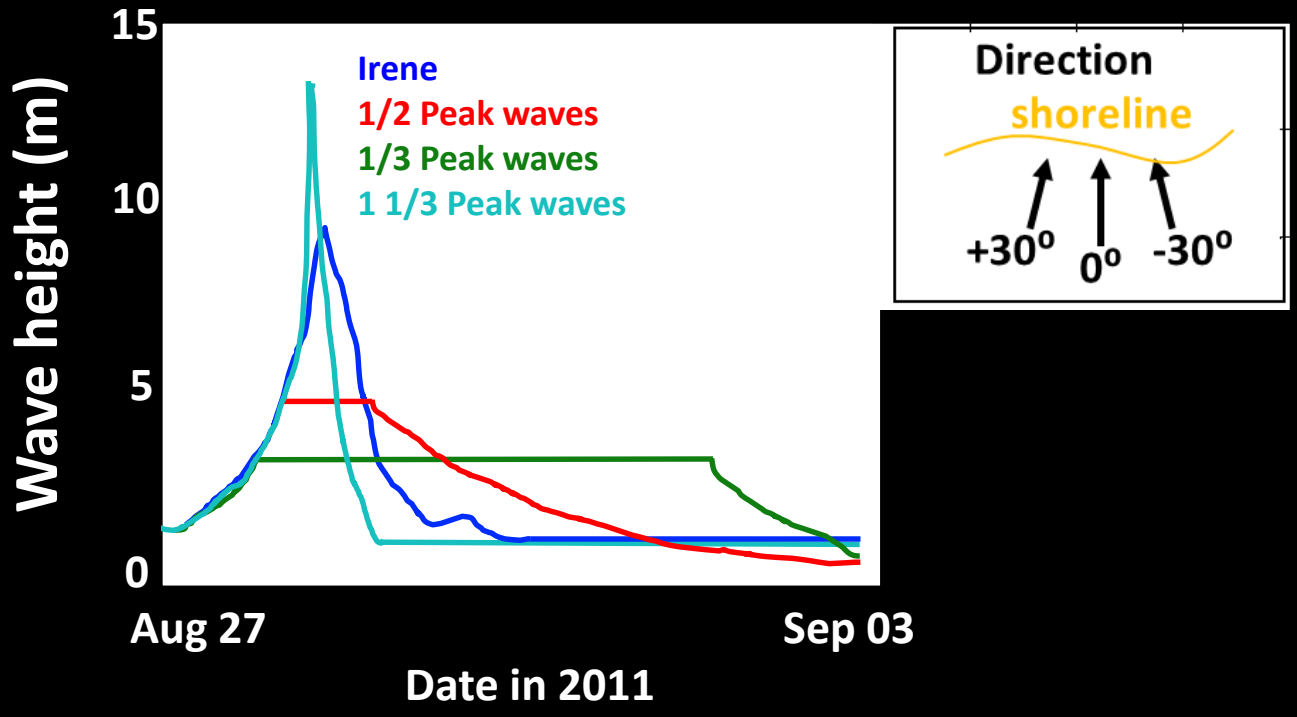
Hurricane intensity > nor'easter intensity



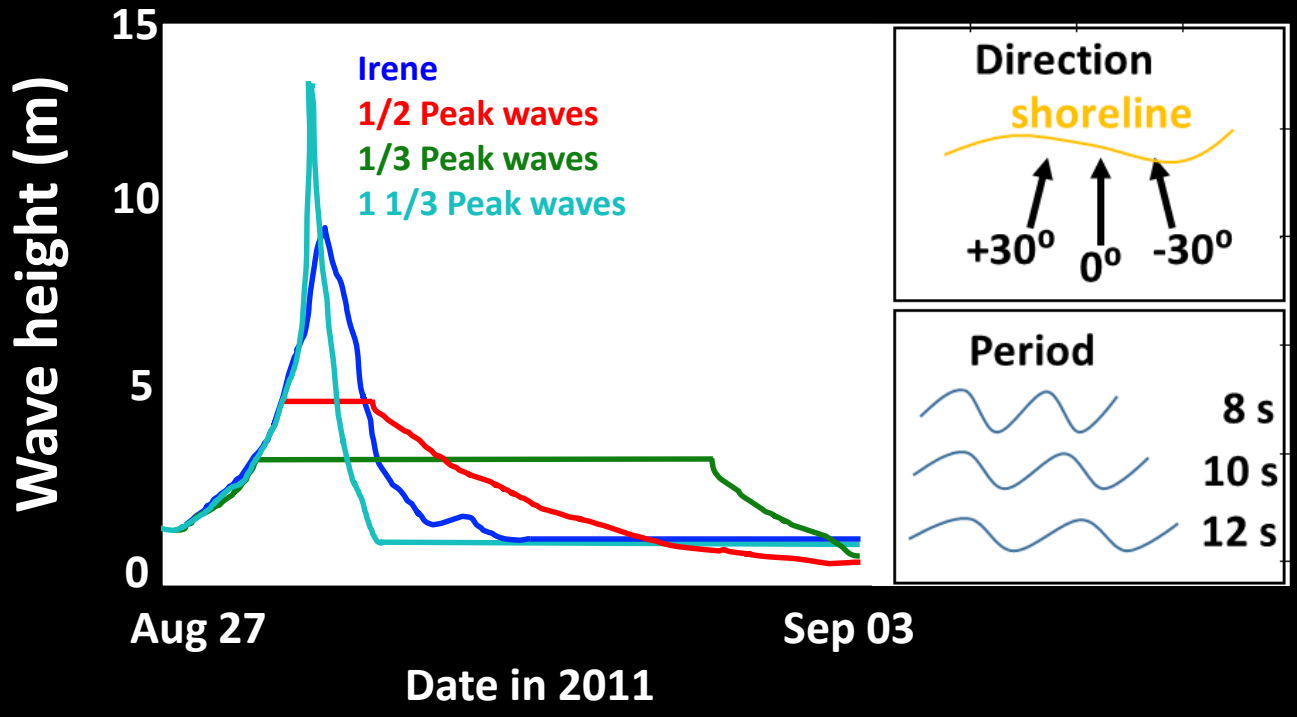
Simulate 1 week of evolution for equal total energy, different peaks



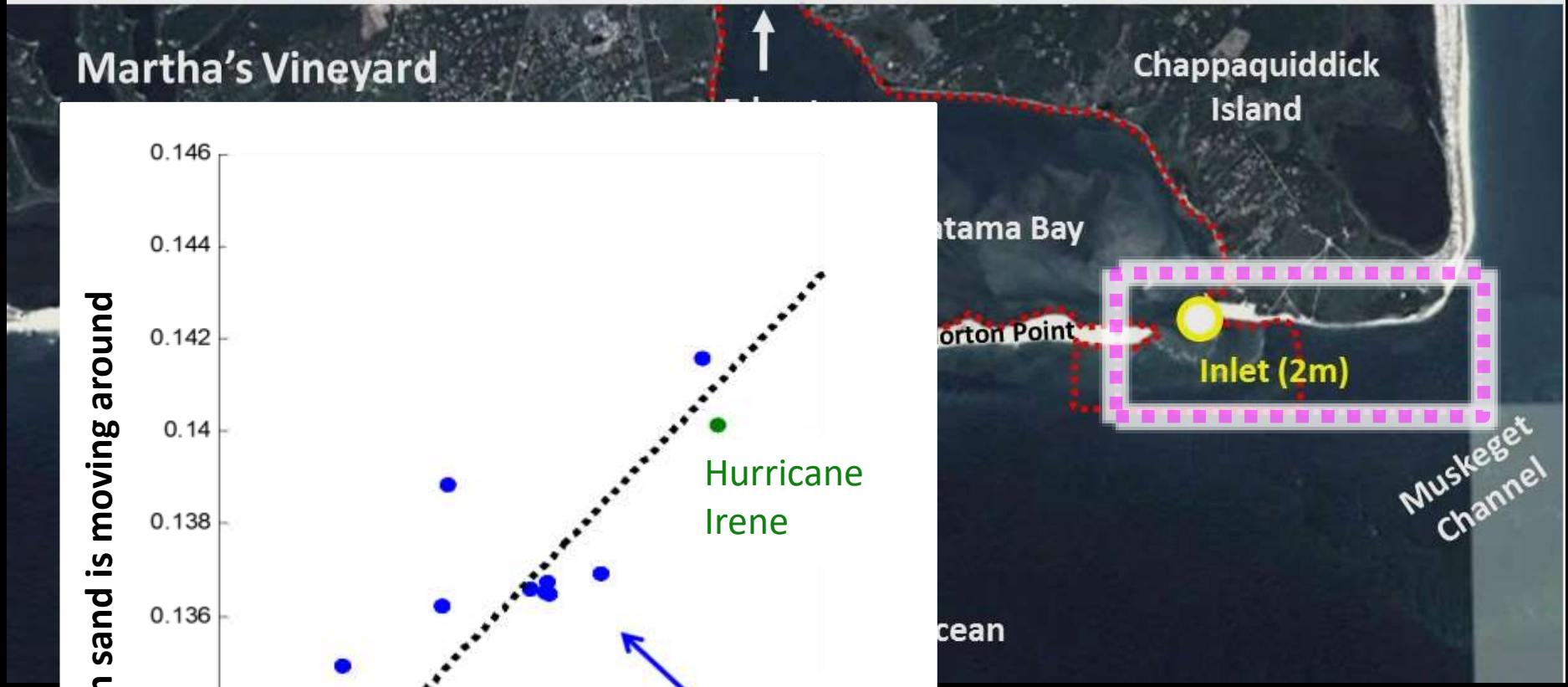
Simulate 1 week of evolution for equal total energy, different peaks

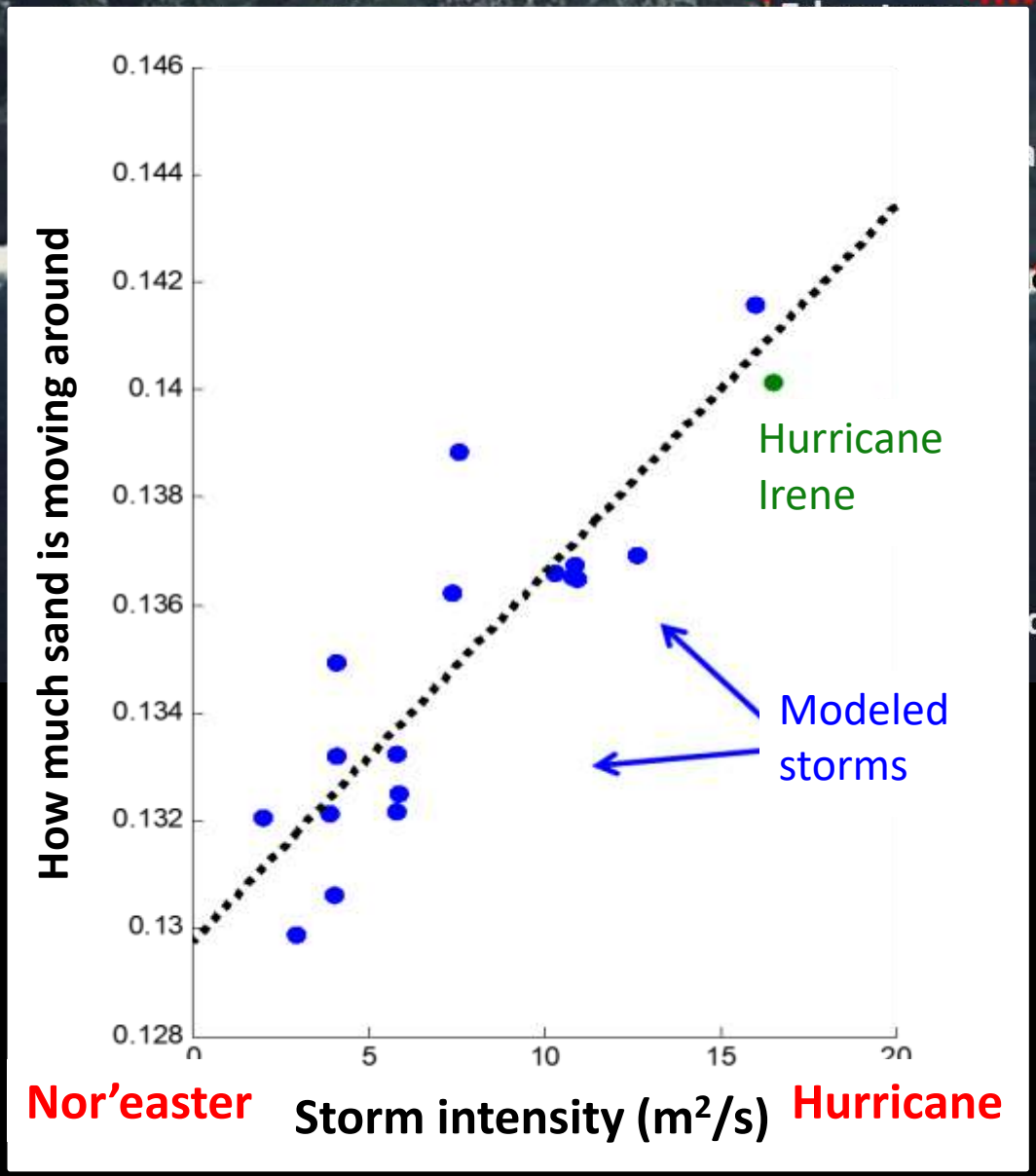


Simulate 1 week of evolution for equal total energy, different peaks

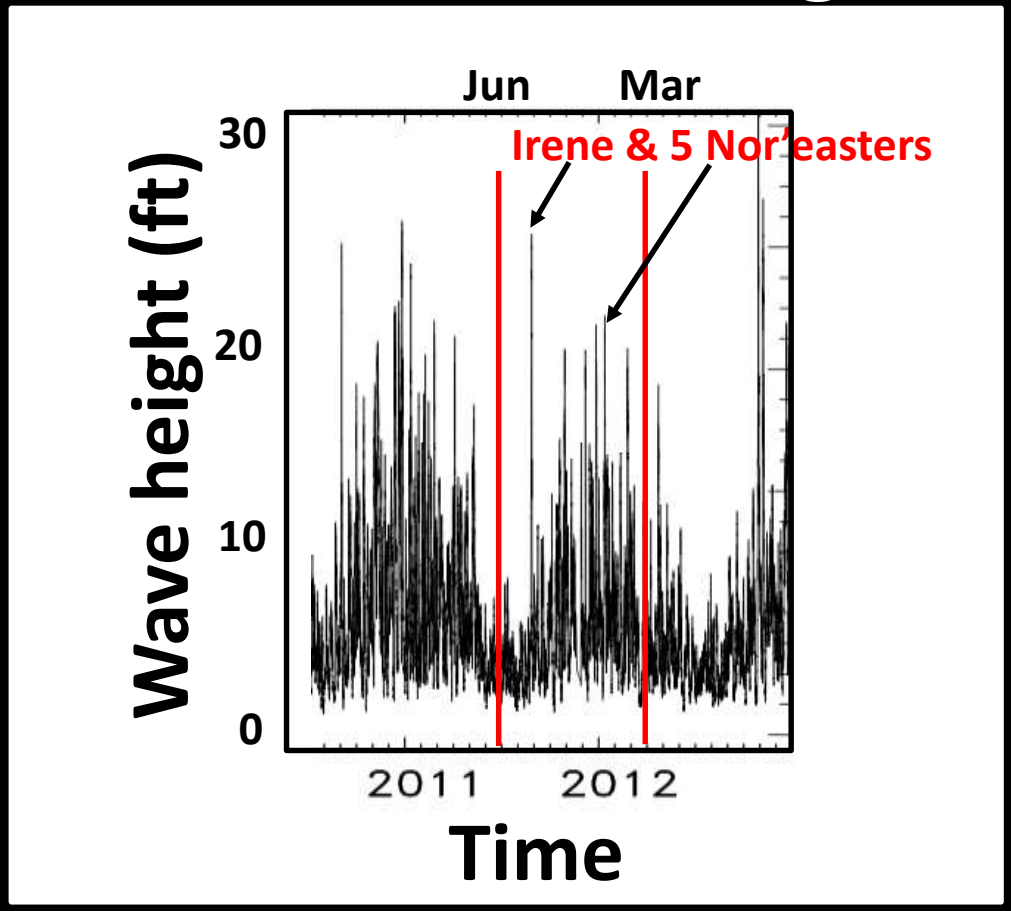



Martha's Vineyard
(2011 Shoreline)
Edgartown
Channel
Chappaquiddick
Island
Katama Bay
Norton Point
Inlet (2m)
1 km
Muskeget
Channel
MVCO (12m)
Atlantic Ocean


Martha's Vineyard
Chappaquiddick Island
tama Bay
orton Point
Inlet (2m)
Muskeget Channel
cean


How much sand is moving around
0.146
0.144
0.142
0.14
0.138
0.136
0.134
0.132
0.13
0.128
0
5
10
15
20
Hurricane Irene
Modeled storms
Nor'easter
Storm intensity (m²/s)
Hurricane

Offshore wave height



Conclusions

Tidal current transport

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Tidal current transport

- moves sediment along inlet channel
- hinders sediment deposition (scours channel)

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Wave-driven transport

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- deposits sediment into the inlet
- moves sediment eastward

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Waves enhance inlet infilling and migration

Hurricanes move more sand than nor'easters (but there are more nor'easters!)


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