BOSTON UNIVERSITY

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Implications of Causeway Removal on Longshore Sediment Transport During Storms in a Complex Shoreline System

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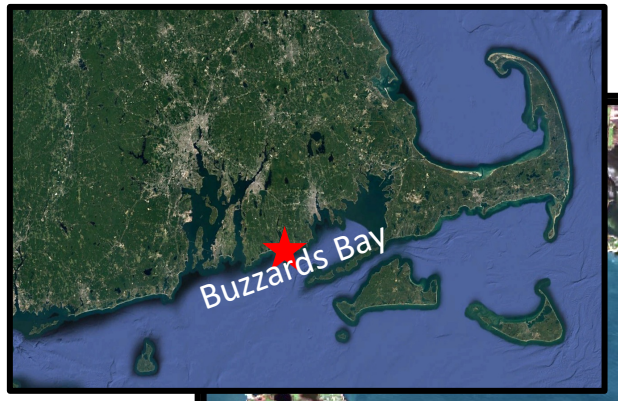
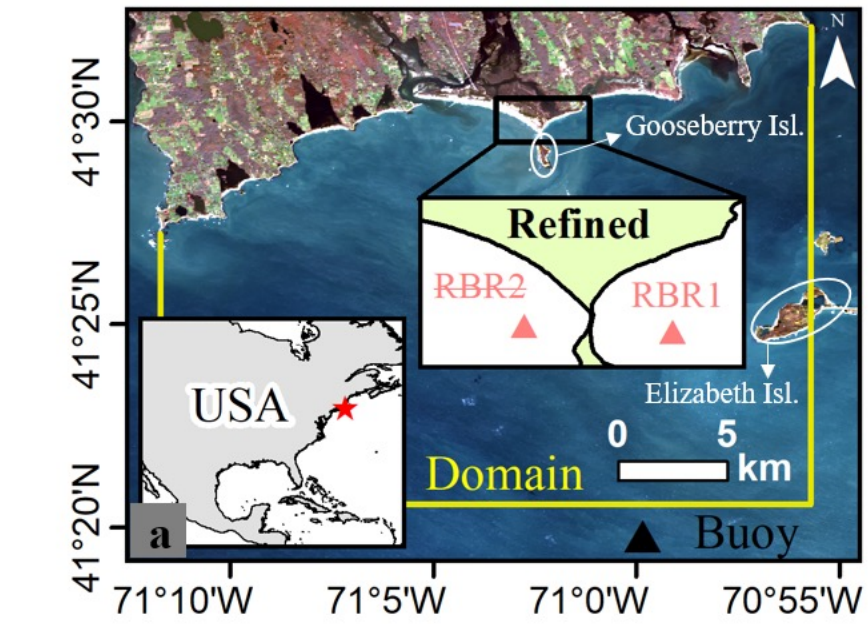
*Funded by the Buzzards Bay Coalition through a grant from The Rathmann Family Foundation

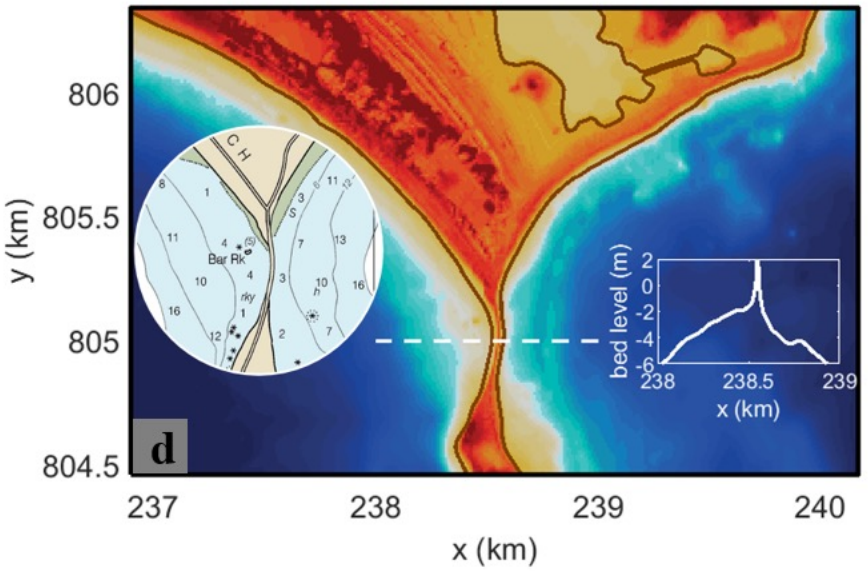
Causeway at Western Buzzards Bay

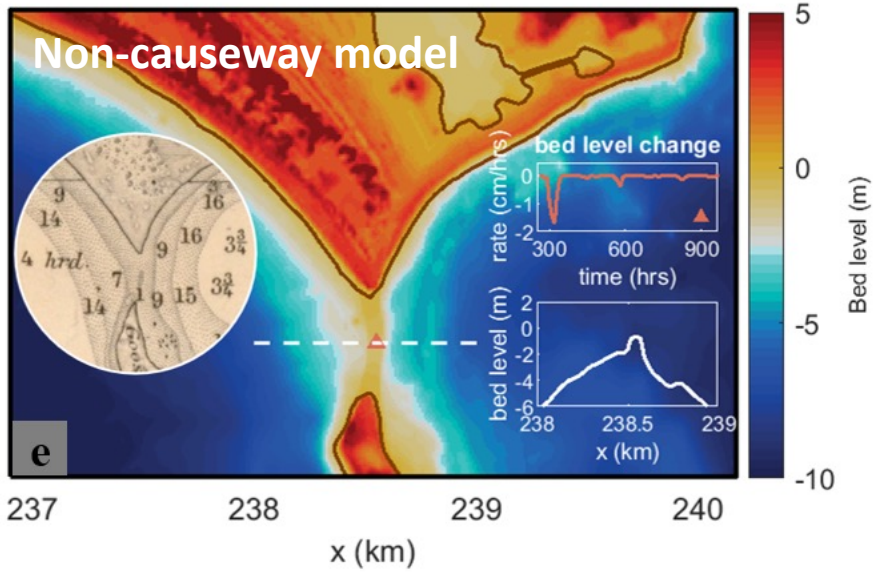


To restore shoreline degradation on the east domain due to the sand supply limitation and SLR, a strategy to remove the causeway has been proposed without proof.

Development of Delft3D Flow-Wave Model







Domain decomposition technique:

- Large model grid: 40 by 40 m
- Refined model grid: 10 m by 10 m

Non-causeway model:

1. Remove causeway
2. Run the model until bed level changes were moderate
3. Equal elevation at the tombolo between model and map

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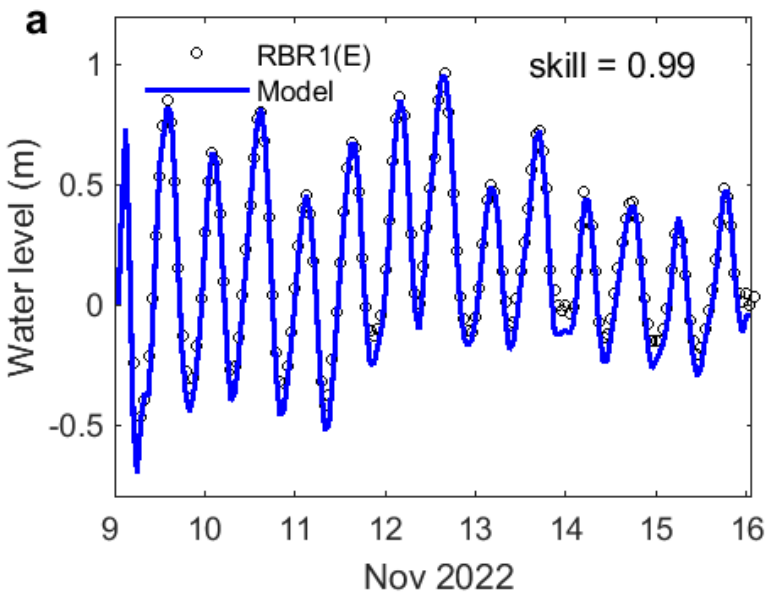

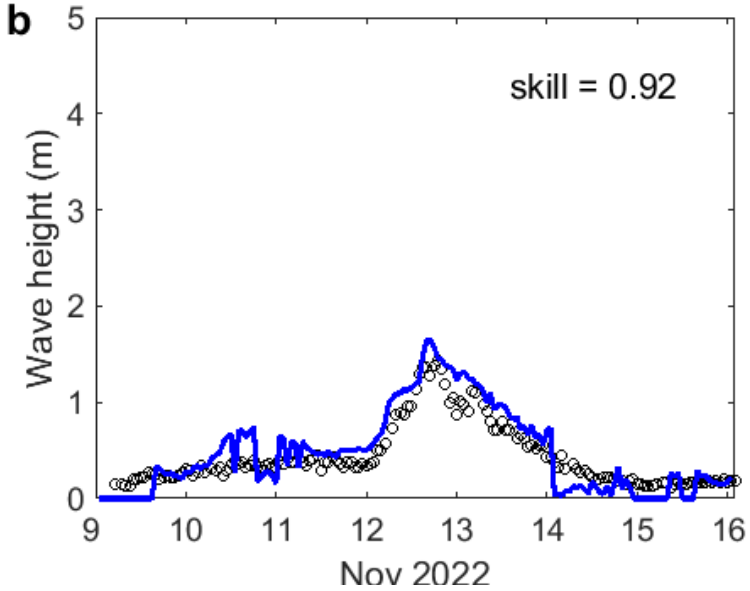

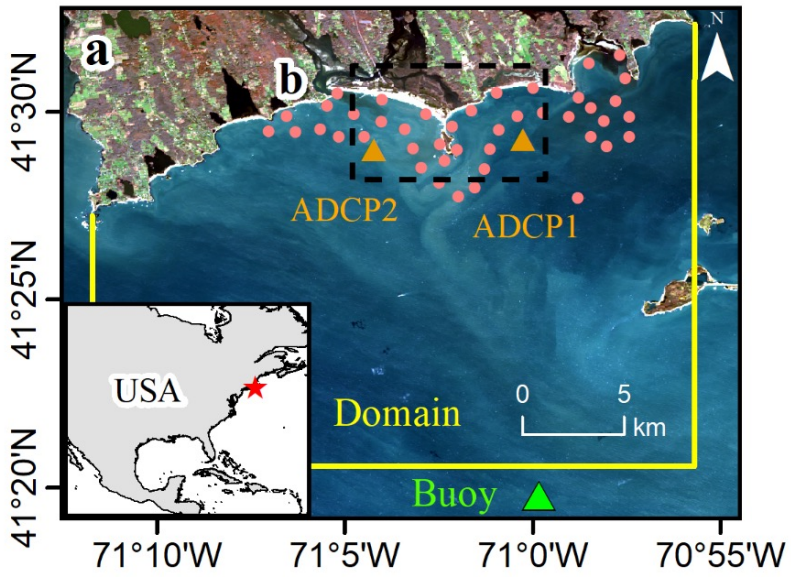

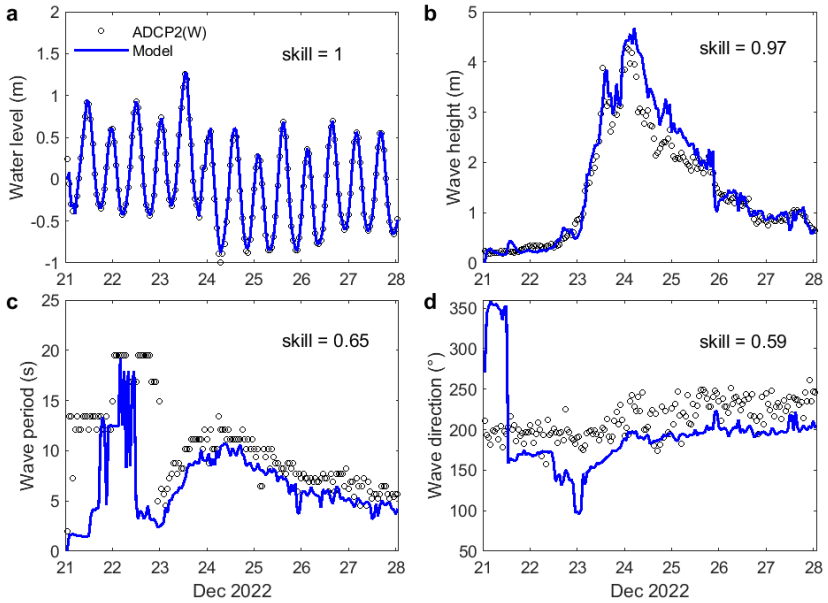

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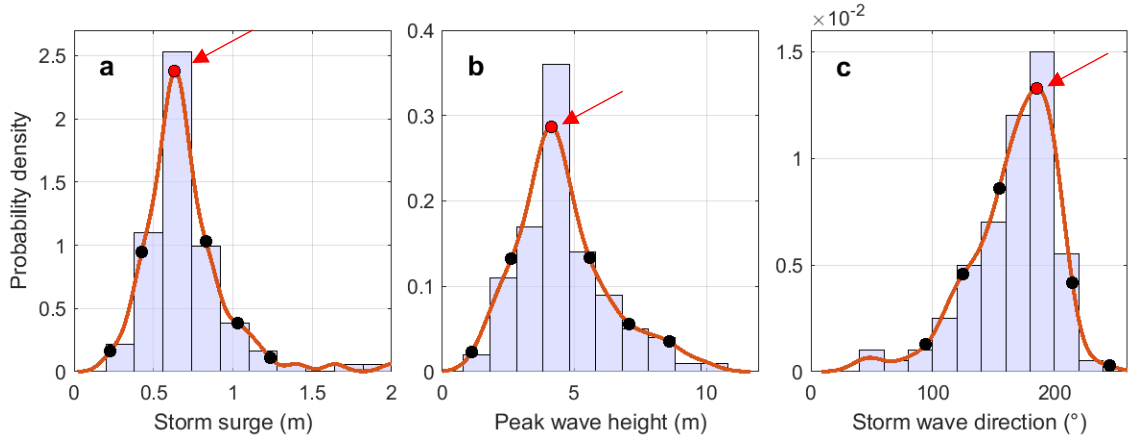
Model validation:

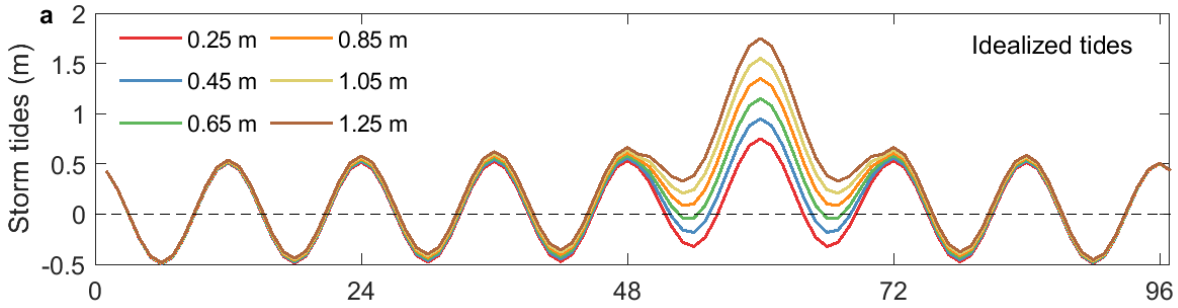
1. RBR1
2. RBR2 (lost)
3. 2 ADCPs and 40 CHS points (Coastal Hazards System)

Model Scenarios at Western Buzzards Bay

1. Storm characteristics based on historical storm analysis



Idealized storm conditions



No.	Group	Storm Surge (m)	Storm wave height (m)	Storm wave direction (°)
1	Impacts of storm surge	0.25	**4**	**185**
2		0.45		
3		**0.65**		
4		0.85		
5		1.05		
6		1.25		
7	Impacts of storm wave height	**0.65**	1	**185**
8			2.5	
Same as No. 3			**4**	
9			5.5	
10			7	
11			8.5	
12	Impacts of storm wave direction	**0.65**	**4**	95
13				125
14				155
Same as No. 3				**185**
15				215
16				245
17	Real storms	0.45	5.3	2022-Winter Storm Elliott
18		0.71	8.7	2011-Hurricane Irene
19		2.77	8.8	1991-Hurricane Bob

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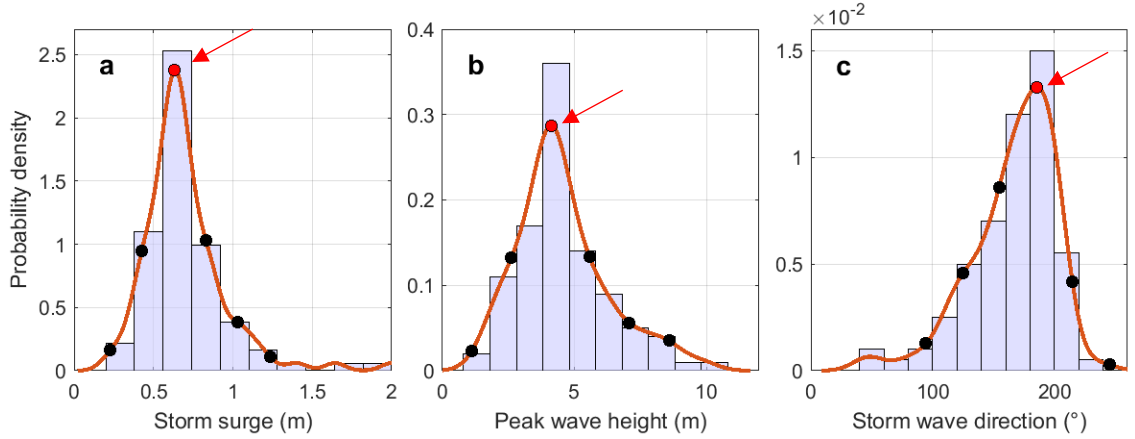

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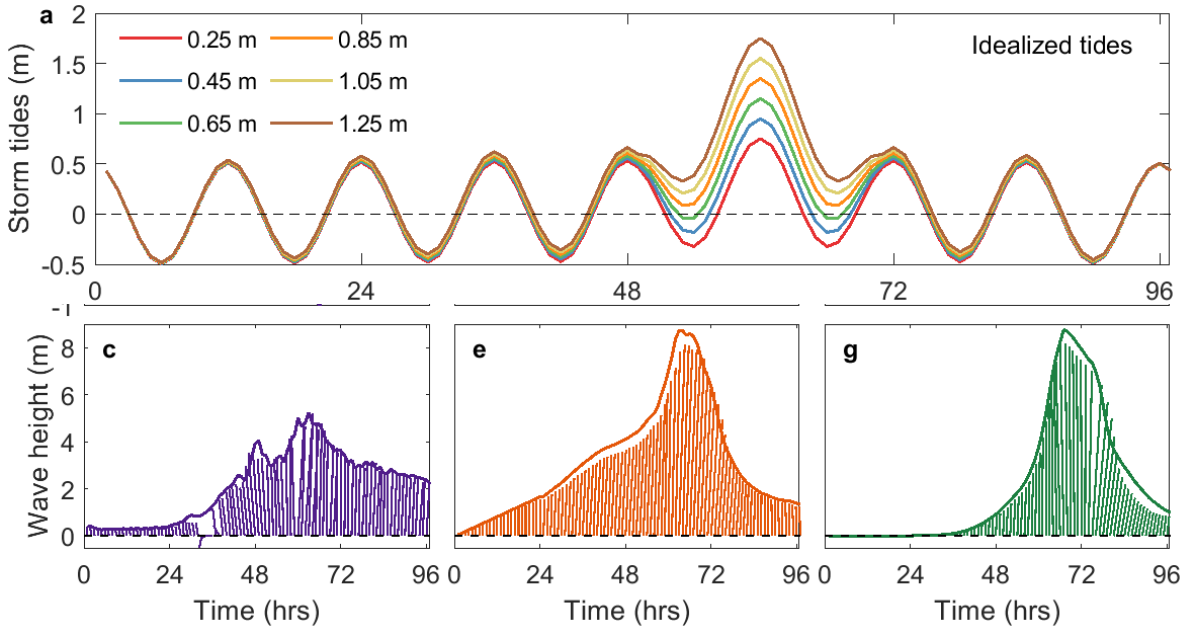

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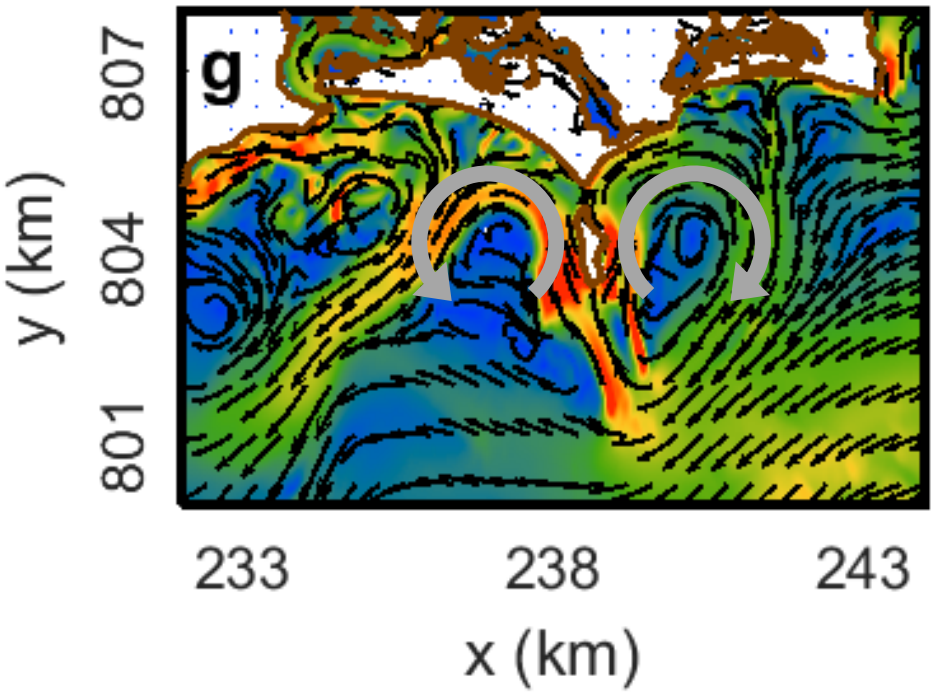
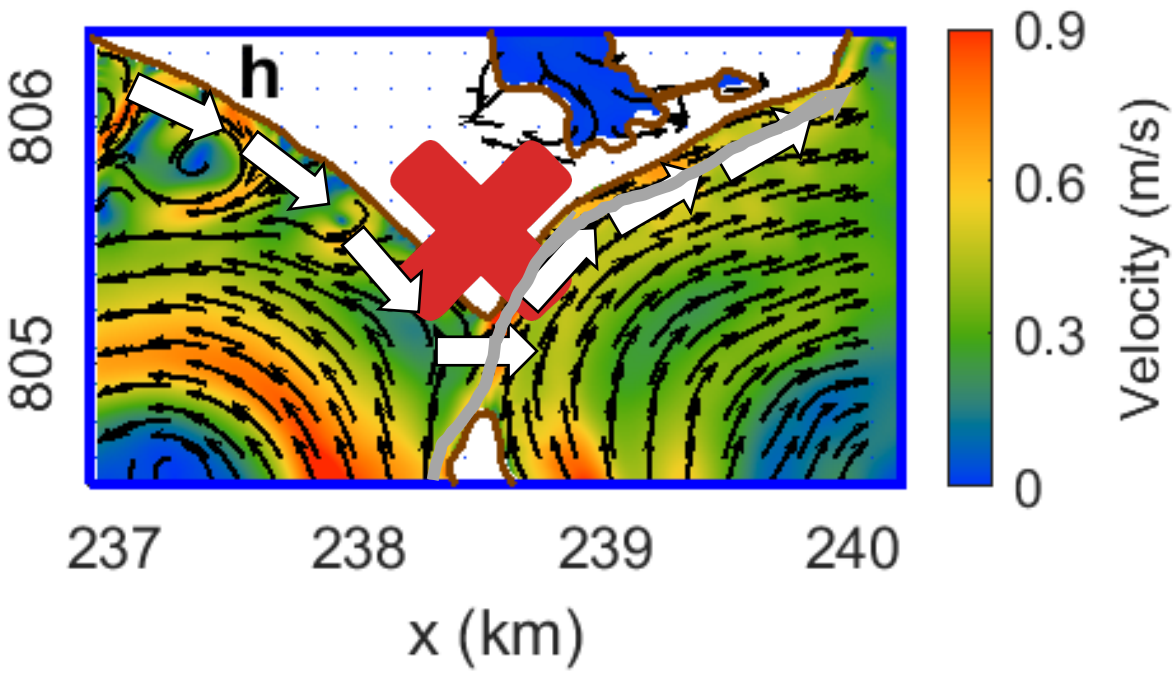
Real storm conditions

Impacts of Storms on Velocity Around Tombolo

Large domain



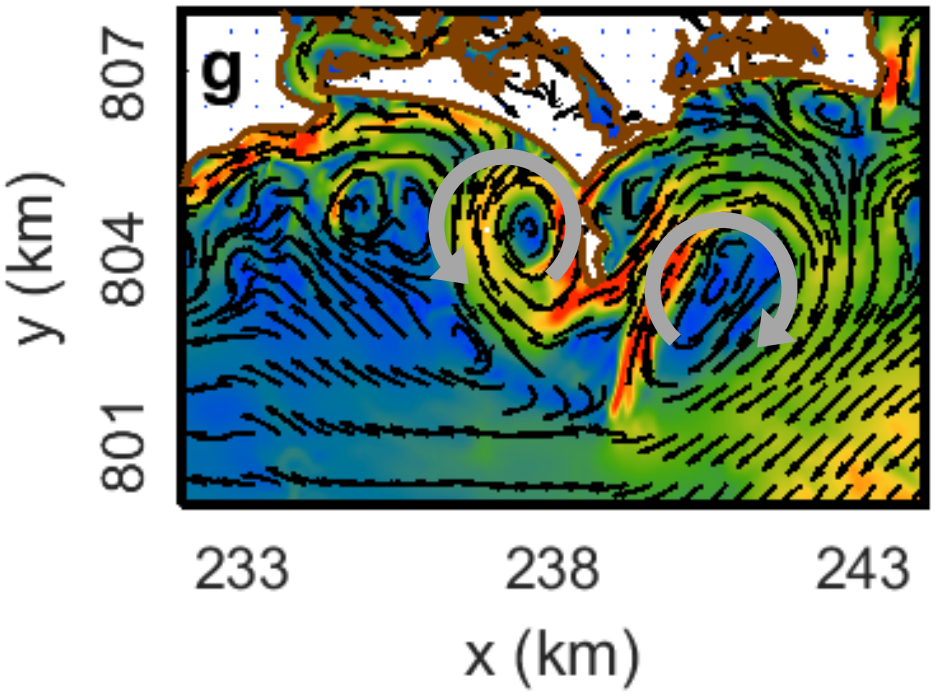
Refined domain



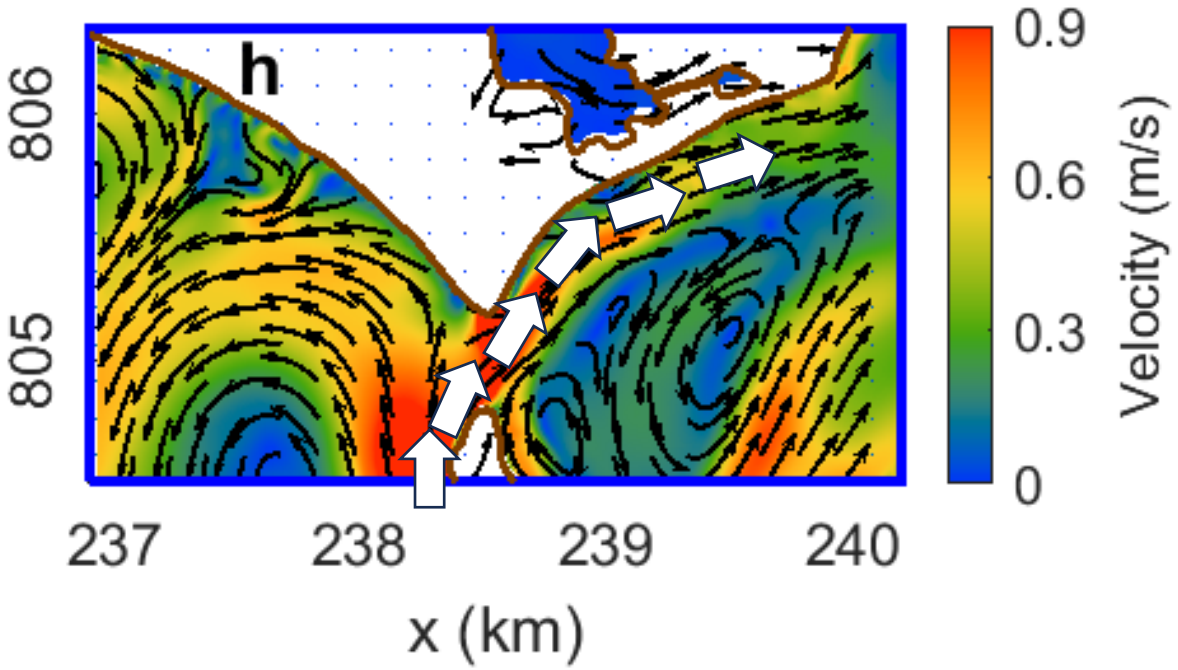
- No longshore currents from beach to beach
- Currents are moving along island to east beach
- Symmetrical circulation cells dominate the currents

When Waves Come From SouthWest

Large domain



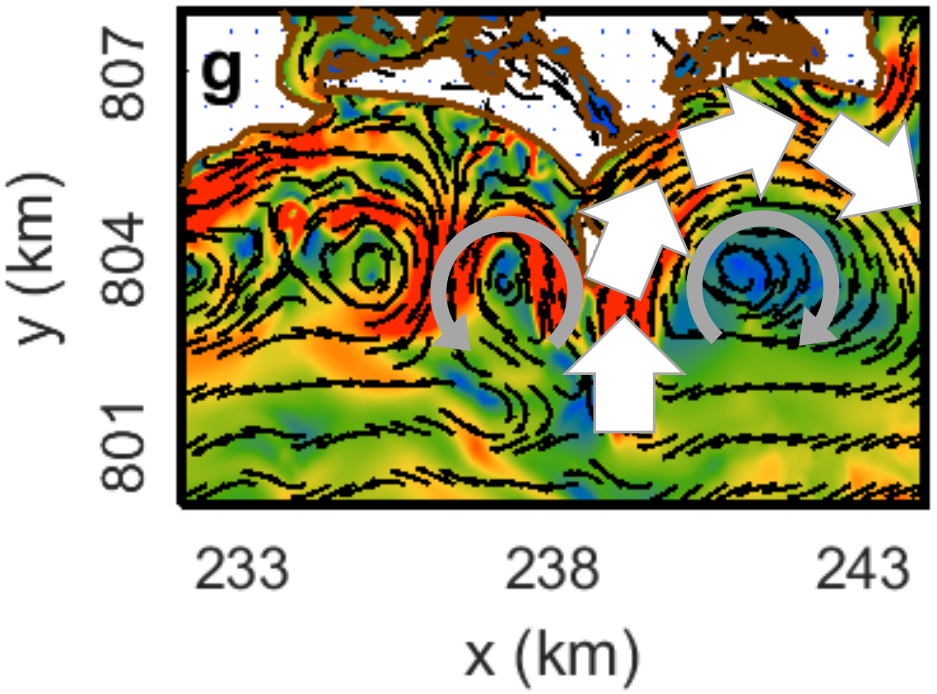
Refined domain



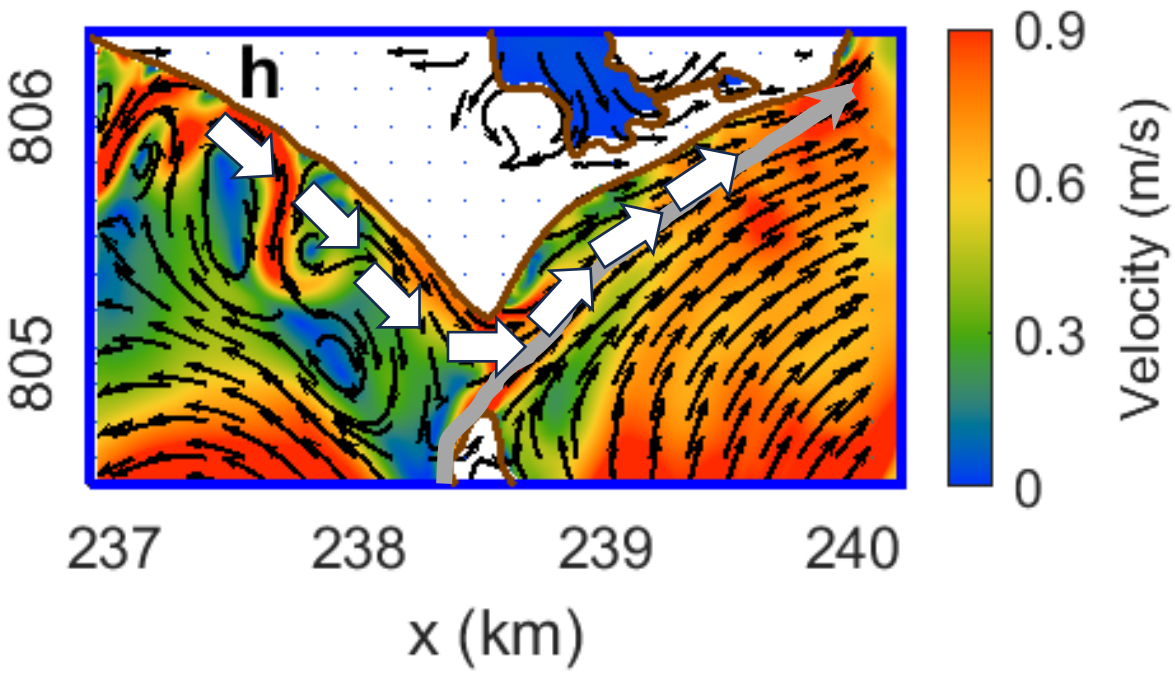
- **Asymmetrical circulation cells**
- **Accelerate currents moving across tombolo from island to east beach**

When Waves Become Larger

Large domain

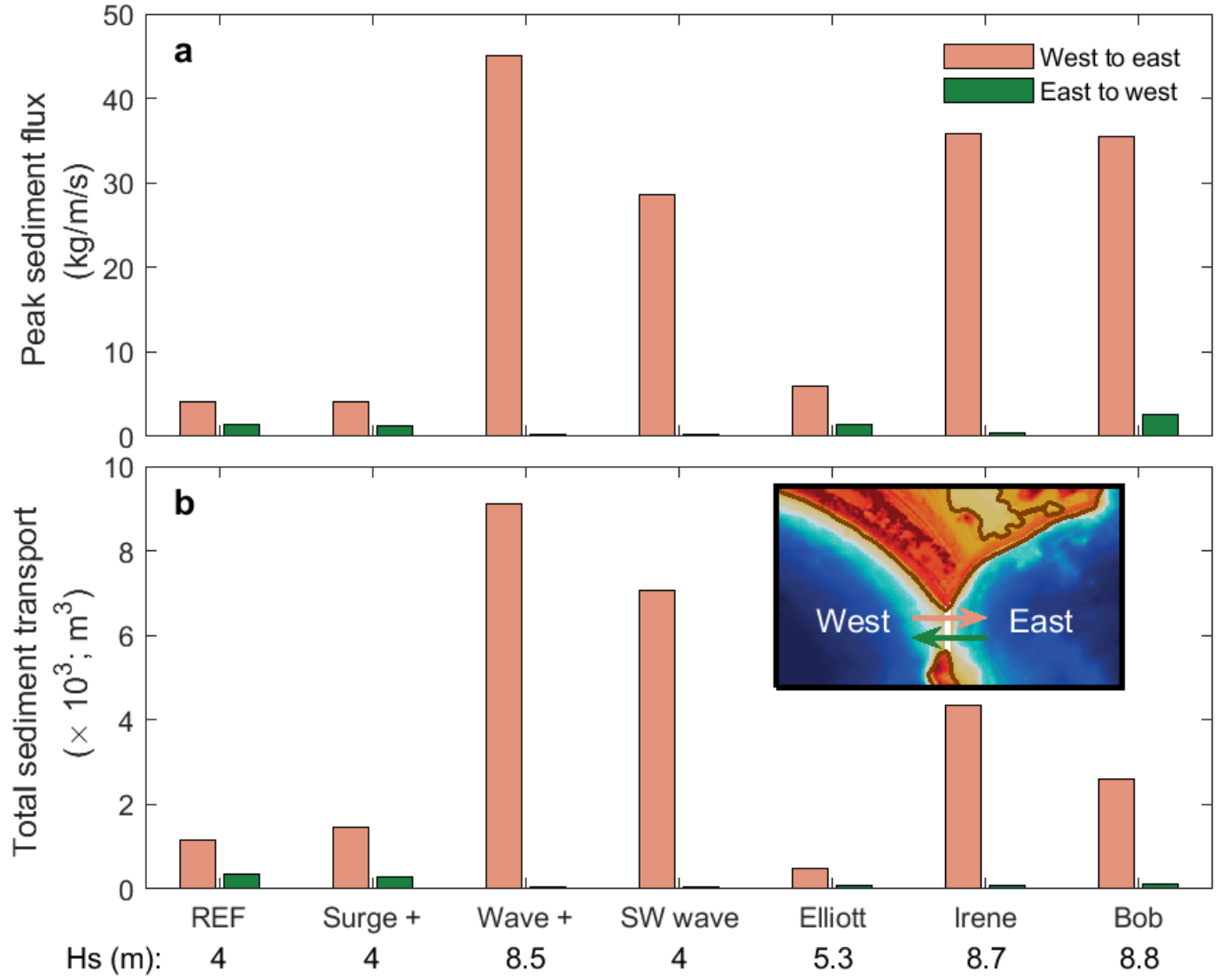


Refined domain



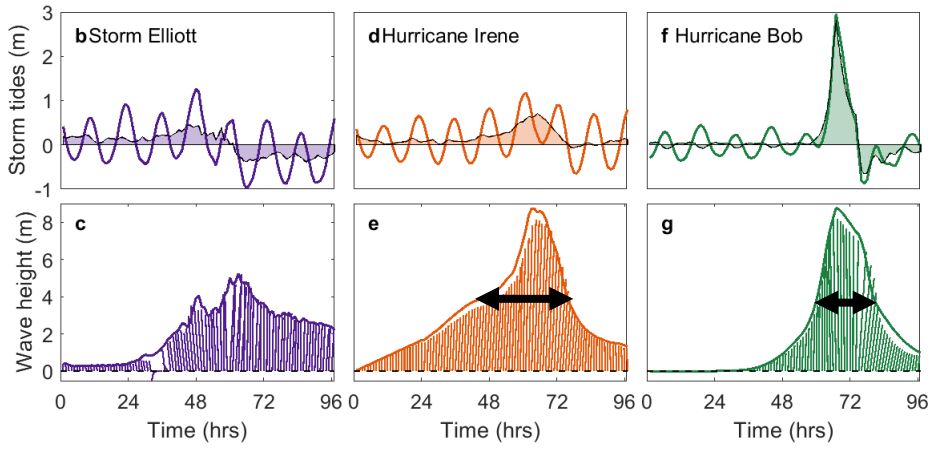
- Circulation cells move offshore, but enlarge velocity field
- New currents from west beach to east beach

Impacts of Storms on Sediment Flux Around Tombolo

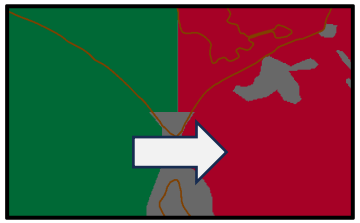


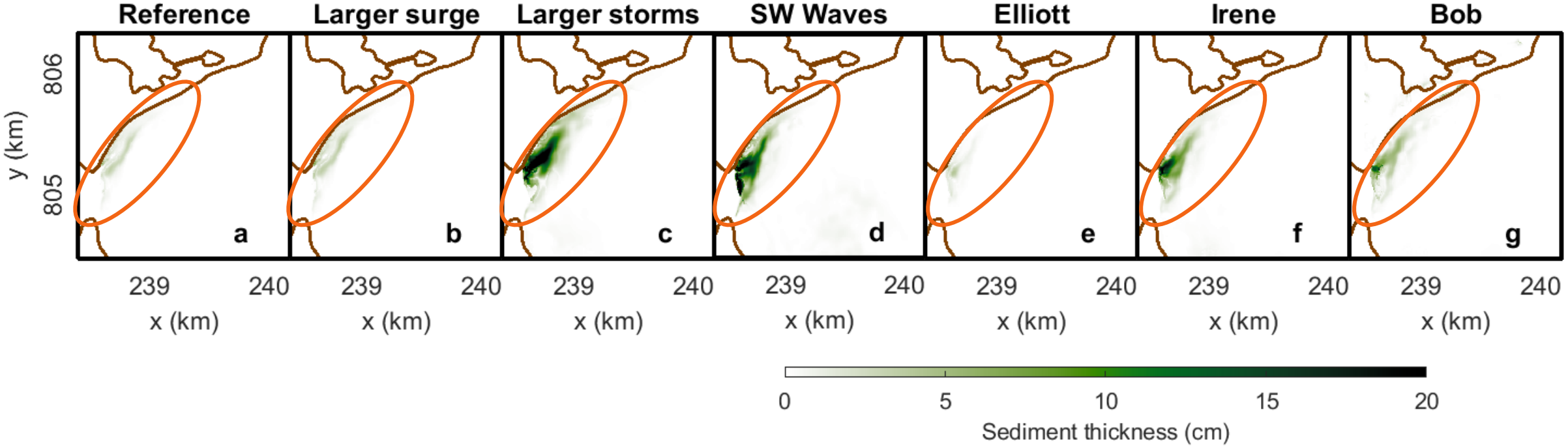
Peak sediment flux across the tombolo to the east beach:

1. REF: West to east is the dominant
2. (Surge +) = REF
3. (Wave +) = REF * 11
4. (SW wave) = REF * 7
5. Storm Elliott < REF (larger but shorter Hs)
6. Peak flux, Hurricane Irene = Hurricane Bob, but for total sediment transport, Irene > Bob



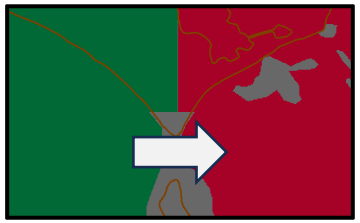
Impacts of Storms on Sediment deposition Around Tombolo

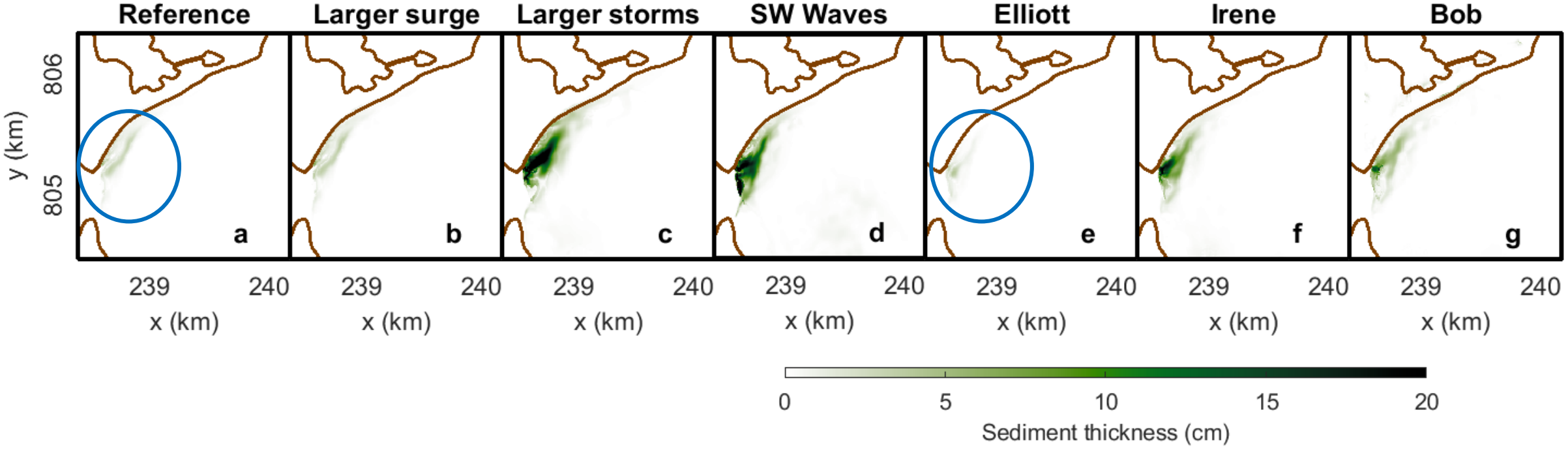




1. Sediment can be transported from the west domain to the east beach

Impacts of Storms on Sediment deposition Around Tombolo

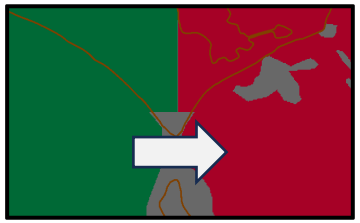


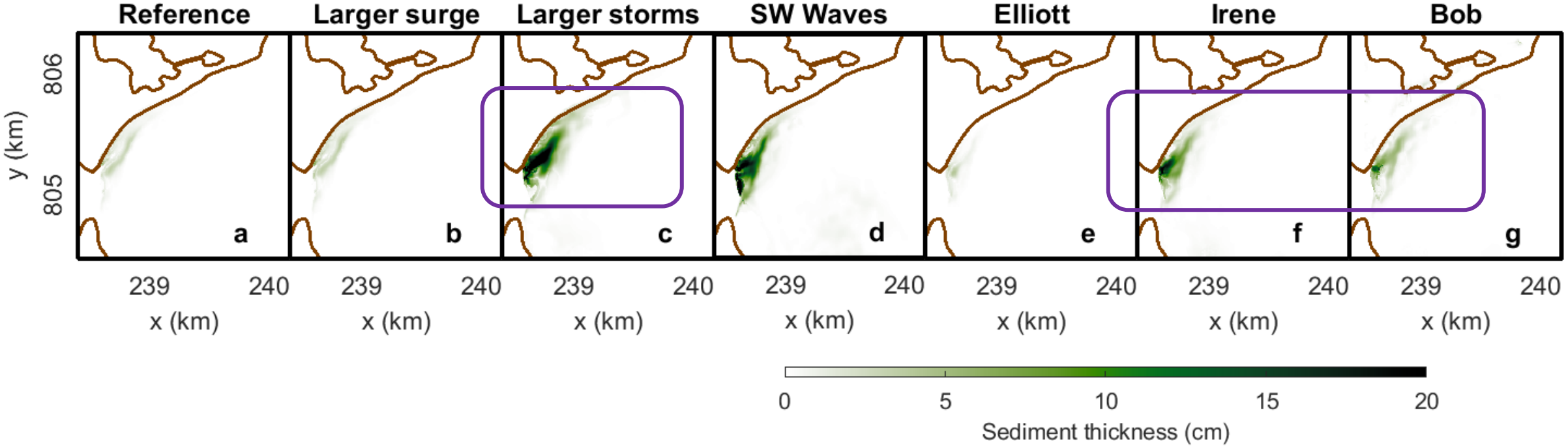


1. Sediment can be transported from the west domain to the east beach

2. The common storm condition might not cause significant sediment deposition

Impacts of Storms on Sediment deposition Around Tombolo



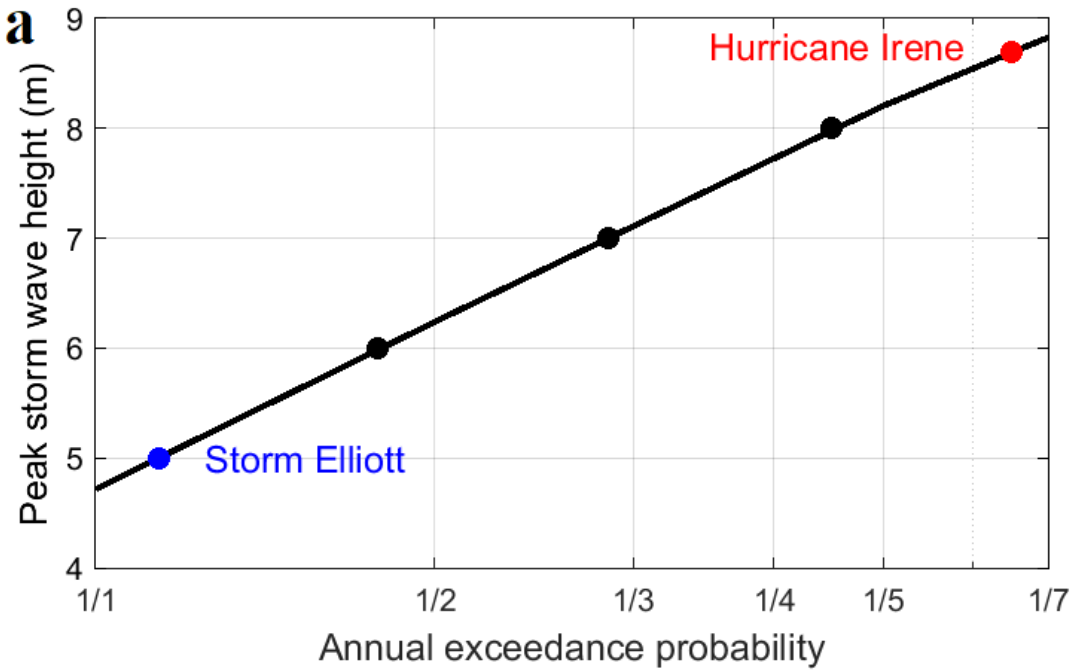


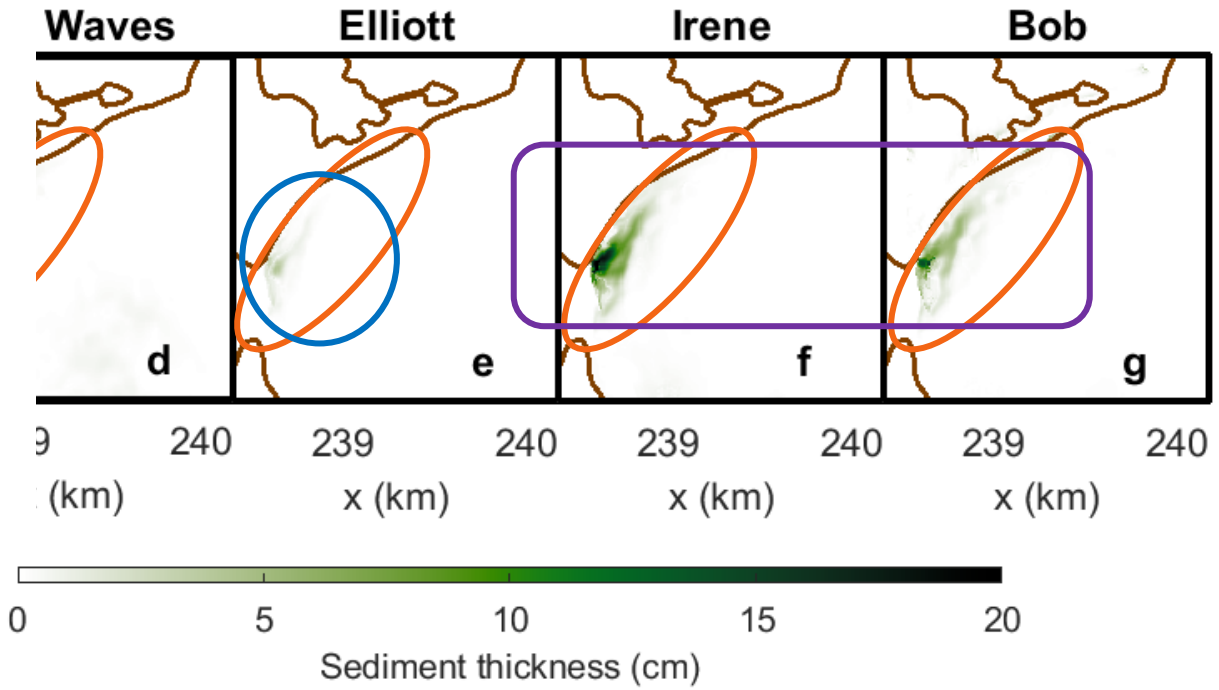
1. Sediment can be transported from the west domain to the east beach

2. The common storm condition might not cause significant sediment deposition

3. The extreme storms could lead to higher sediment deposition, though less common

Impacts of Storms on Sediment deposition Around Tombolo





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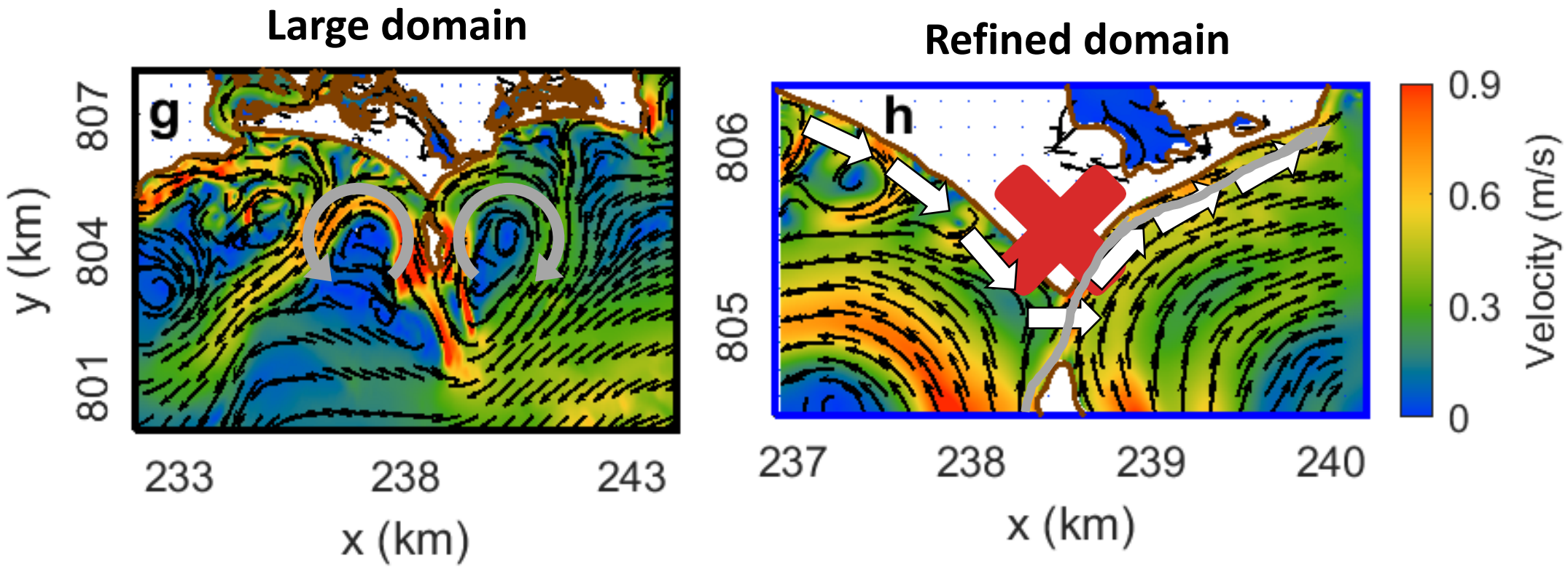
Conclusions

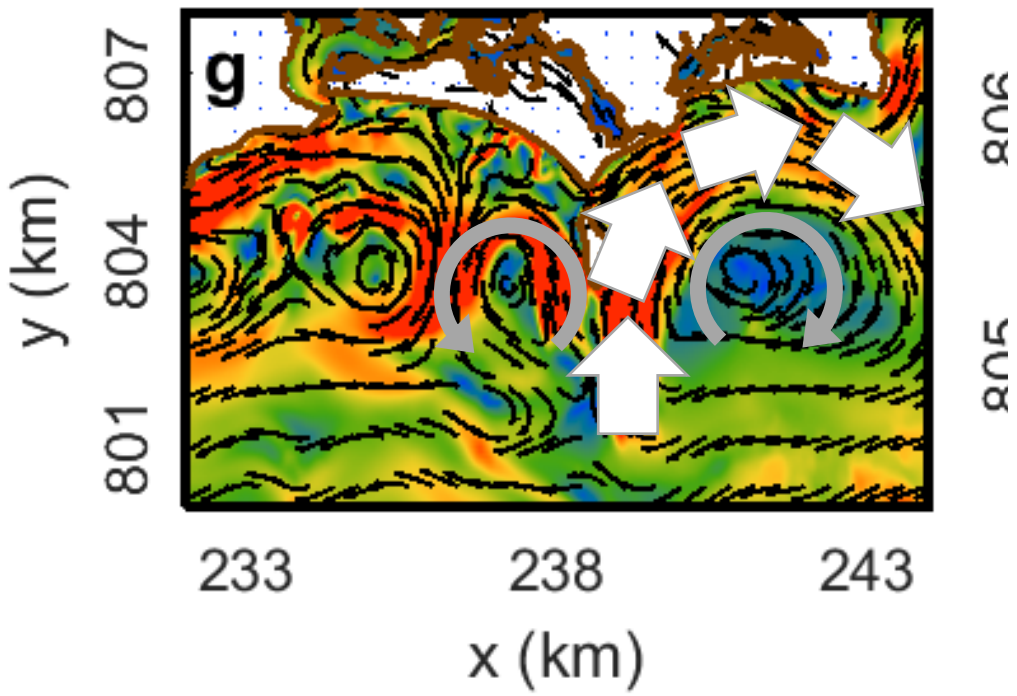
1. Storm-Driven Circulation Cells: Crucial for nearshore currents



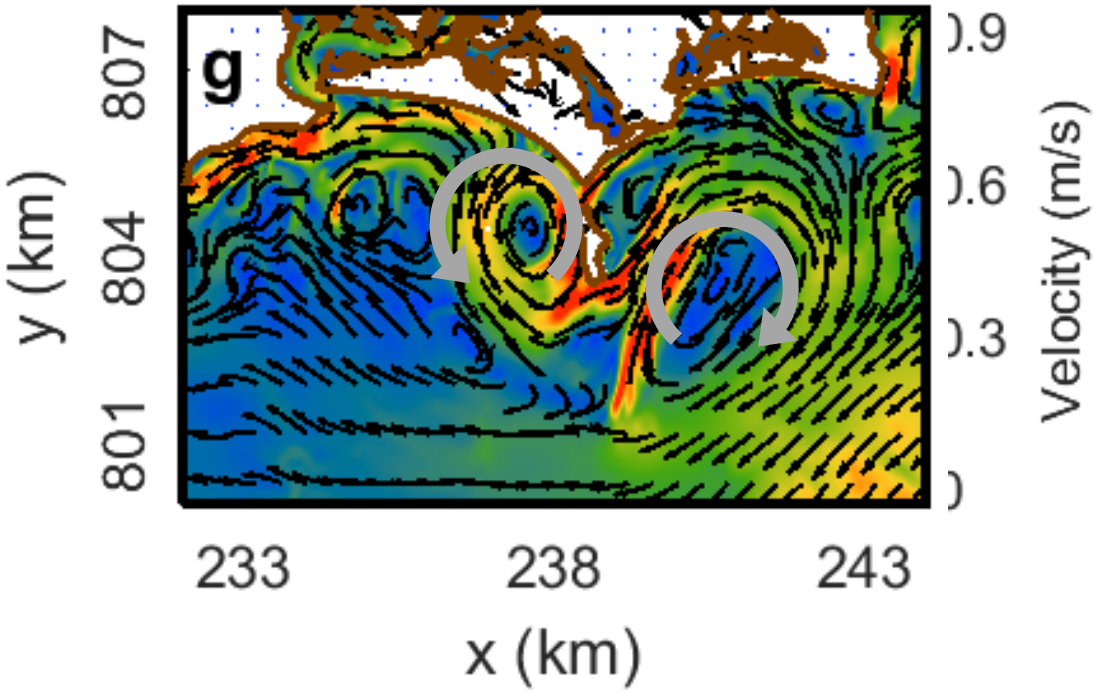
Conclusions

1. **Storm-Driven Circulation Cells:** Crucial for nearshore currents
2. **Wave Dynamics and Sediment Flux:**
    - Larger waves shift circulation offshore
    - SW waves create asymmetrical cells
    - Both amplify sediment flux

Large Waves



SW waves



Conclusions

1. Storm-Driven Circulation Cells: Crucial for nearshore currents

2. Wave Dynamics and Sediment Flux:

- Larger waves shift circulation offshore
- SW waves create asymmetrical cells
- Both amplify sediment flux

3. Causeway Removal Impact:

- Facilitates sediment transport to eastern beach
- Common storm conditions have minimal impact
- Extreme storms, however, can be significant