West Florida Shelf and Tampa Bay Responses to Hurricane Irma: What Happened and Why

R.H. Weisberg
Y. Liu
J. Chen

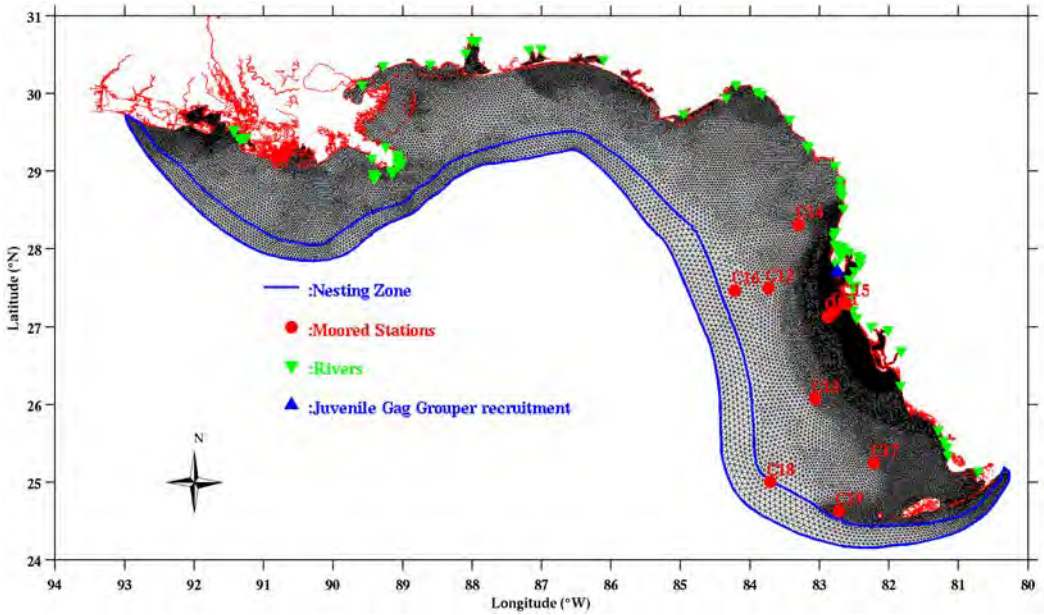
College of Marine Science
University of South Florida
St. Petersburg, FL

SECOORA Webinar
2/13/18

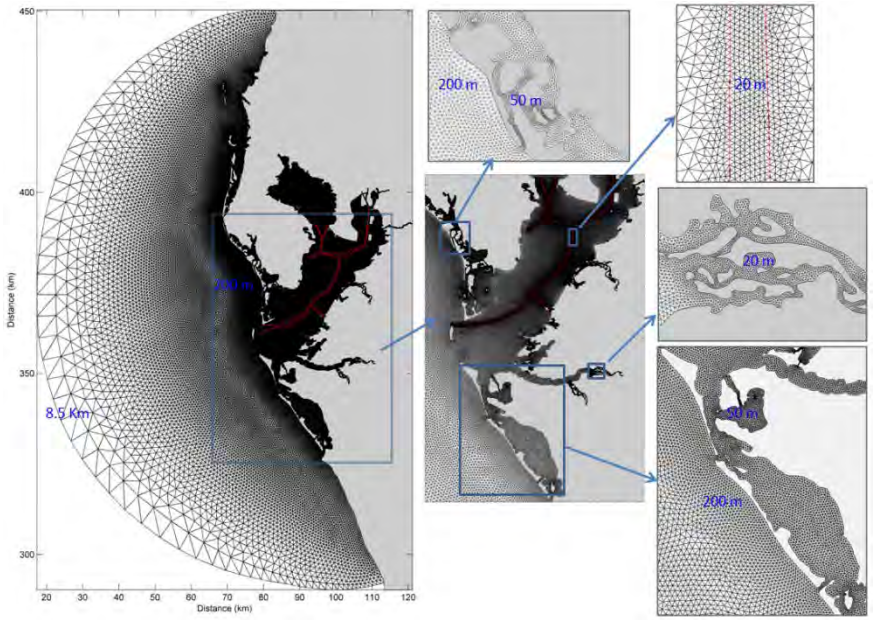
- The Ocean Circulation Group, College of Marine Science – USF maintains a coordinated program of ocean observing and modeling with concentration on the West Florida Shelf and Tampa Bay.
- Deployed during Irma were three real-time buoys along with various coastal stations, and
- Circulation models for the West Florida Shelf and Tampa Bay provided information throughout the storm.

COMPS Buoys

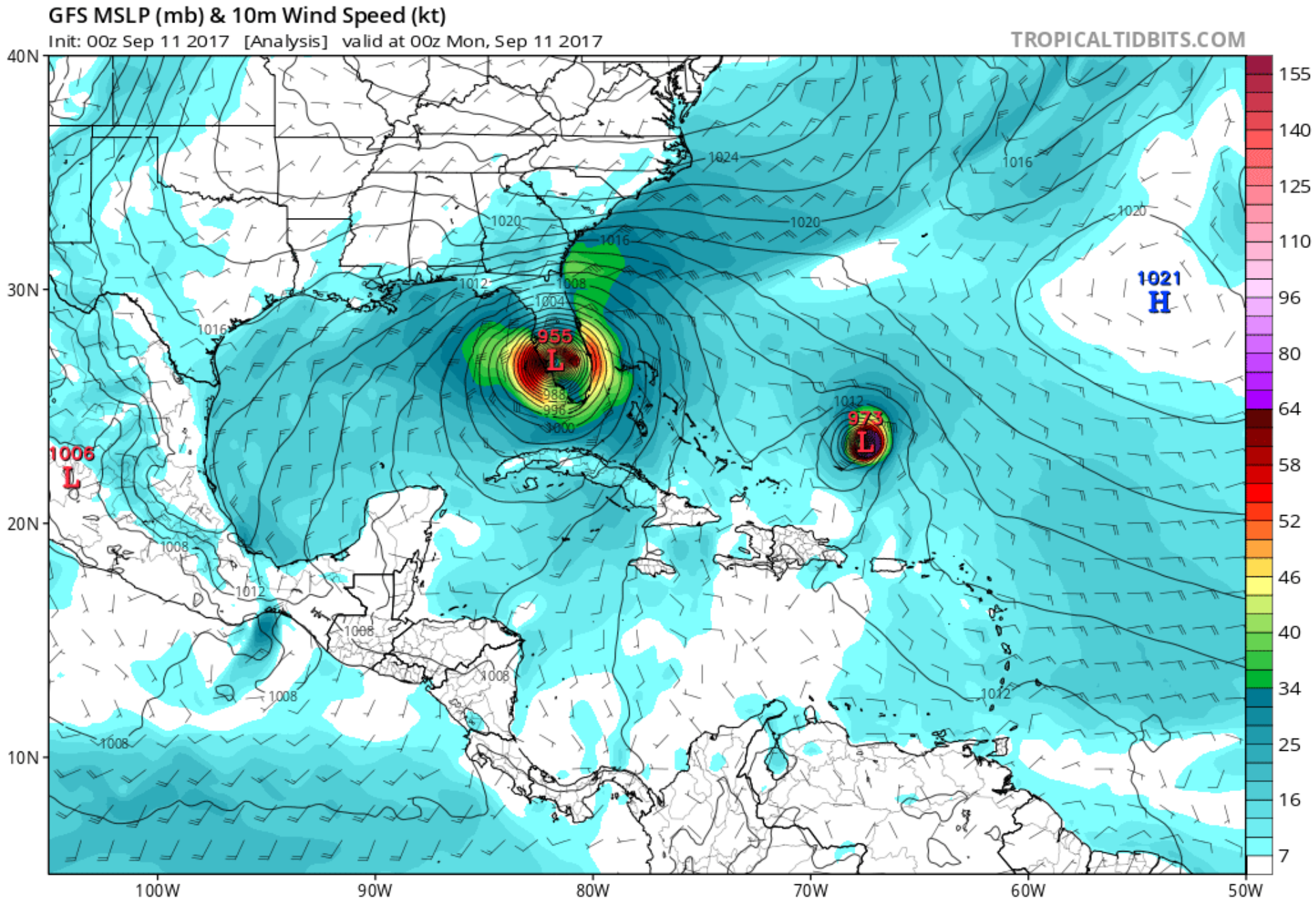
West Florida Coastal Ocean Model FVCOM nested in GOM HYCOM



Tampa Bay Coastal Ocean Model FVCOM nested in WFCOM



GFS Analysis at 0000 UT 9/11/17

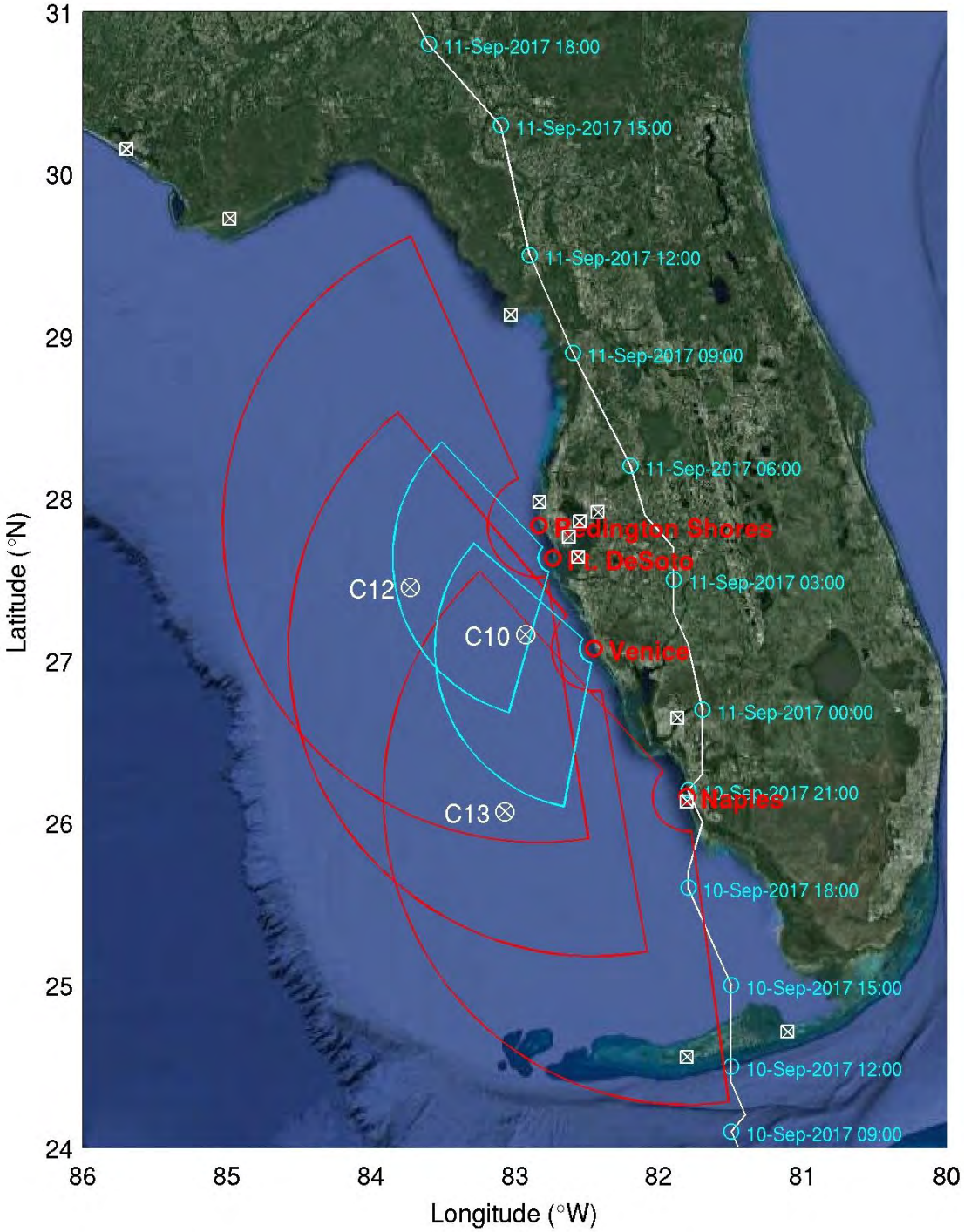


West Florida Shelf Coastal Ocean Observing System (SECOORA-NOAA-IOOS and COMPS)

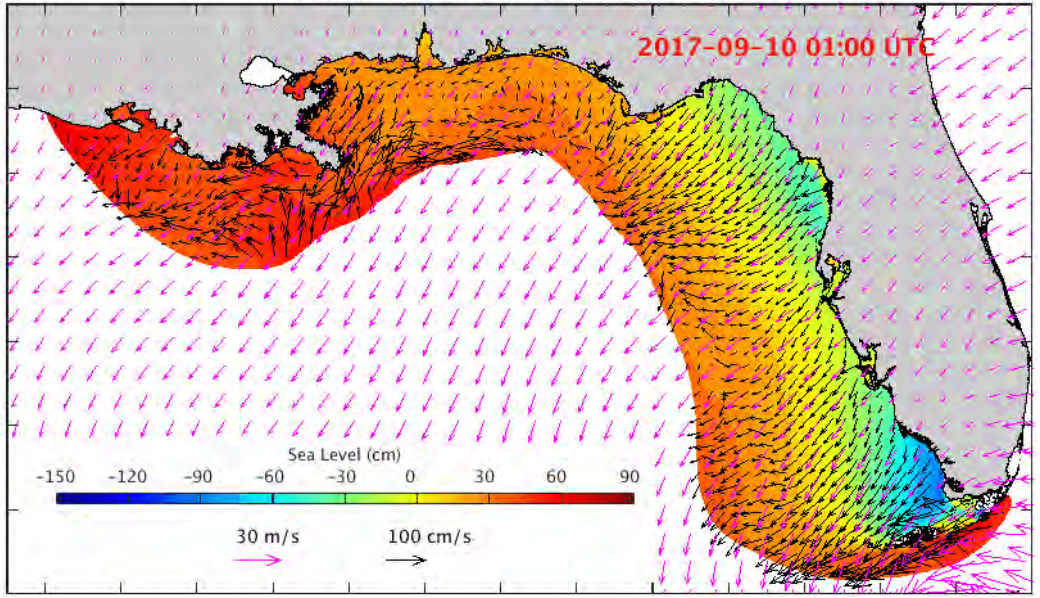
- **Surface buoys with real-time ocean & meteorological sensors**
  - **C10 (25 m site)**
  - **C12 & C13 (50 m sites)**

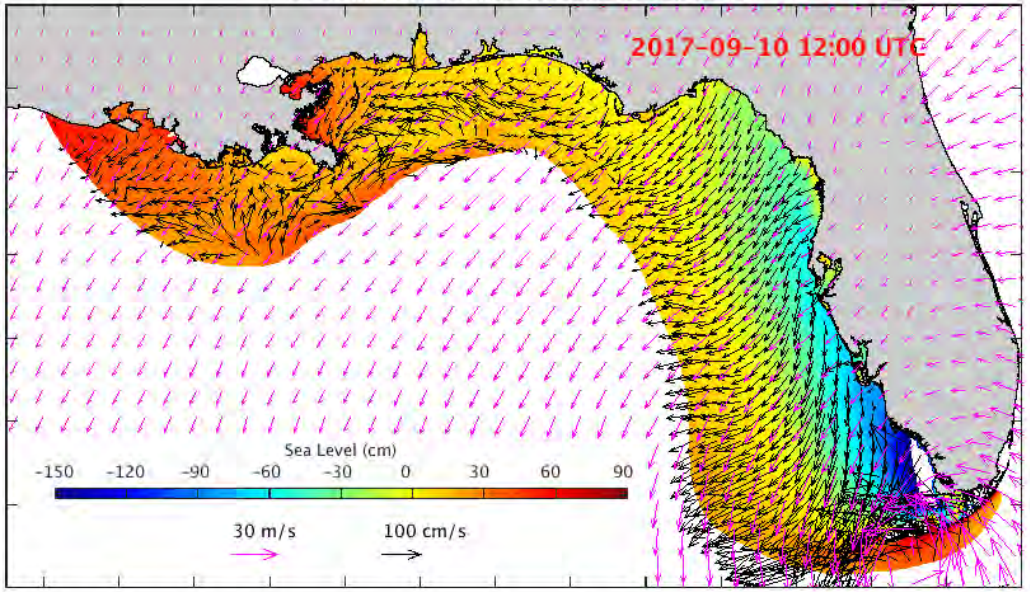
- **High-frequency radar systems:**
  - **3 CODAR SeaSonde systems**
  - **2 WERA systems**

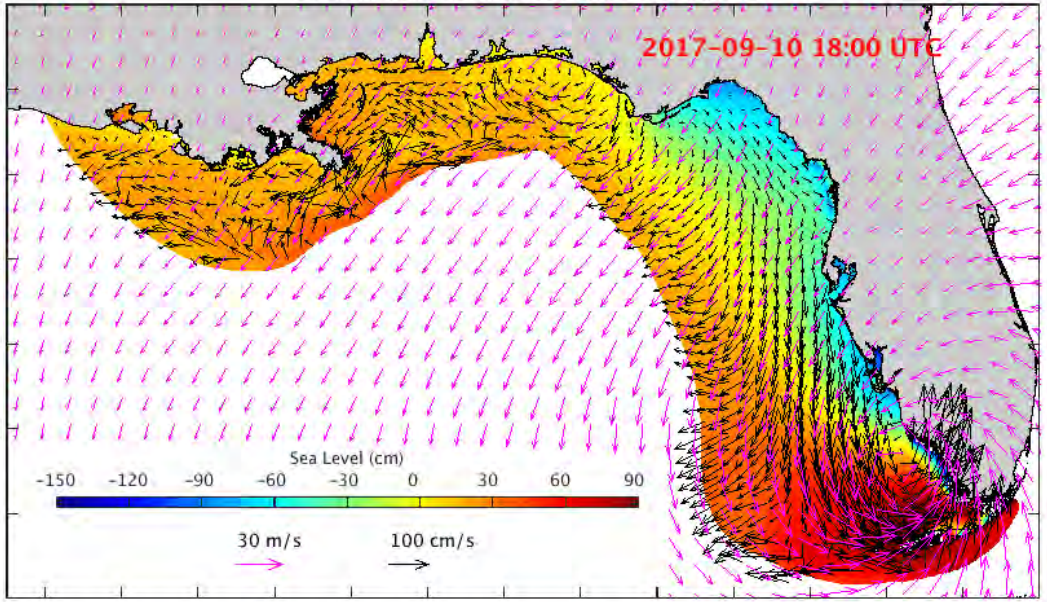
- **Tide gauges (COMPS, NOAA) along the west Florida coast**

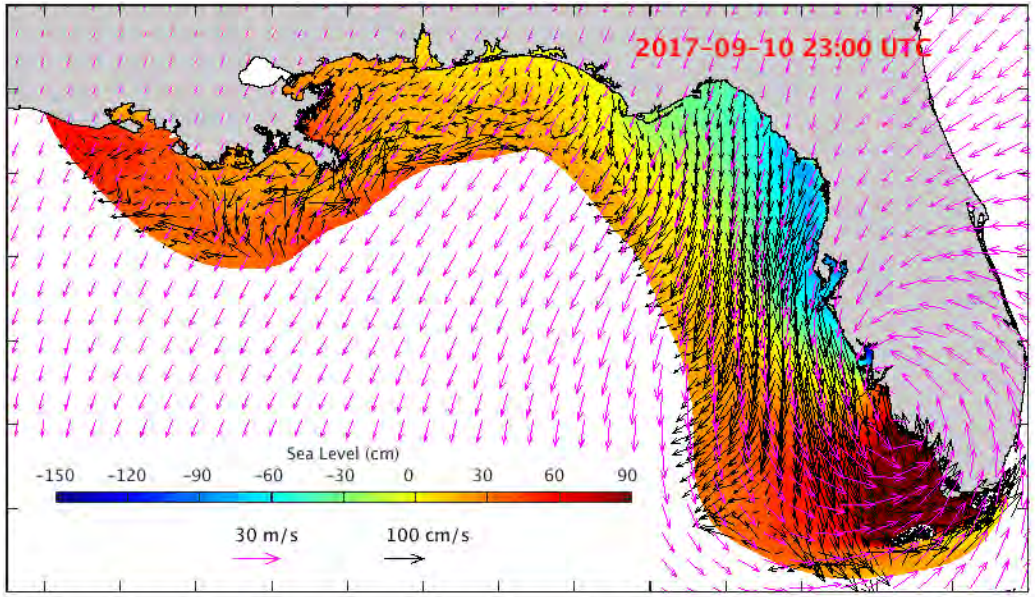


Surface Winds Overlain on WFCOM Simulated Surface Currents and Sea Level (09-10-2017)

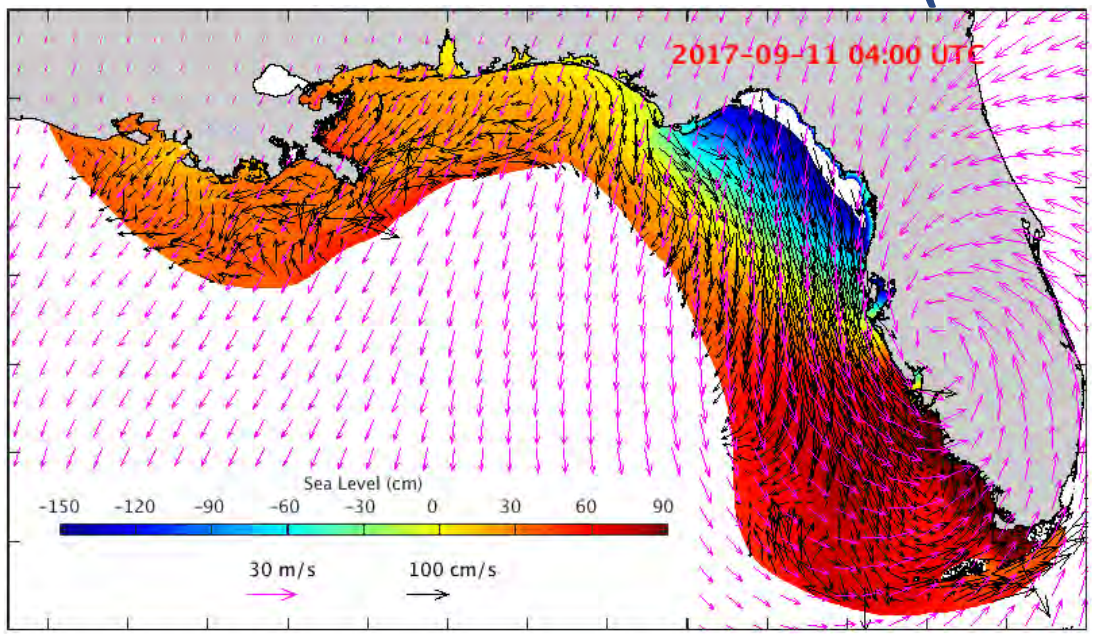


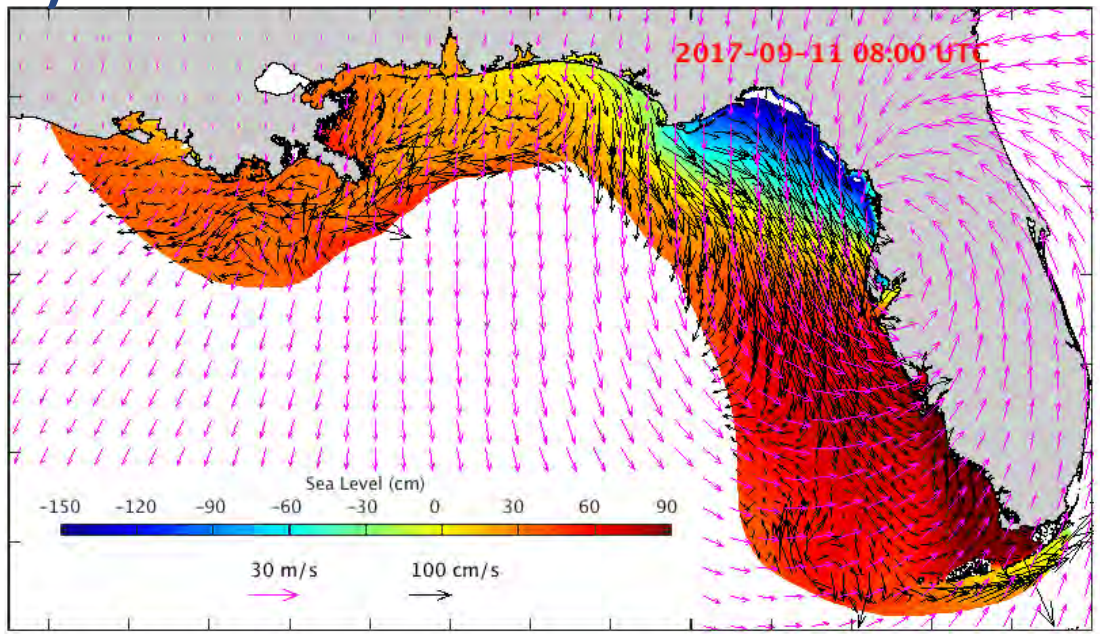


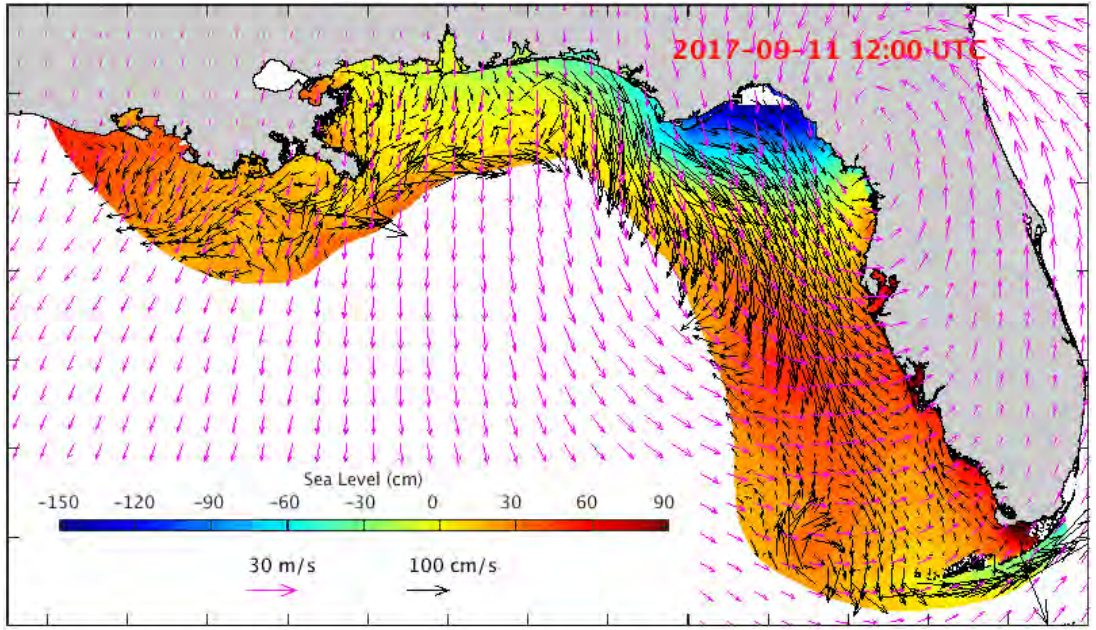


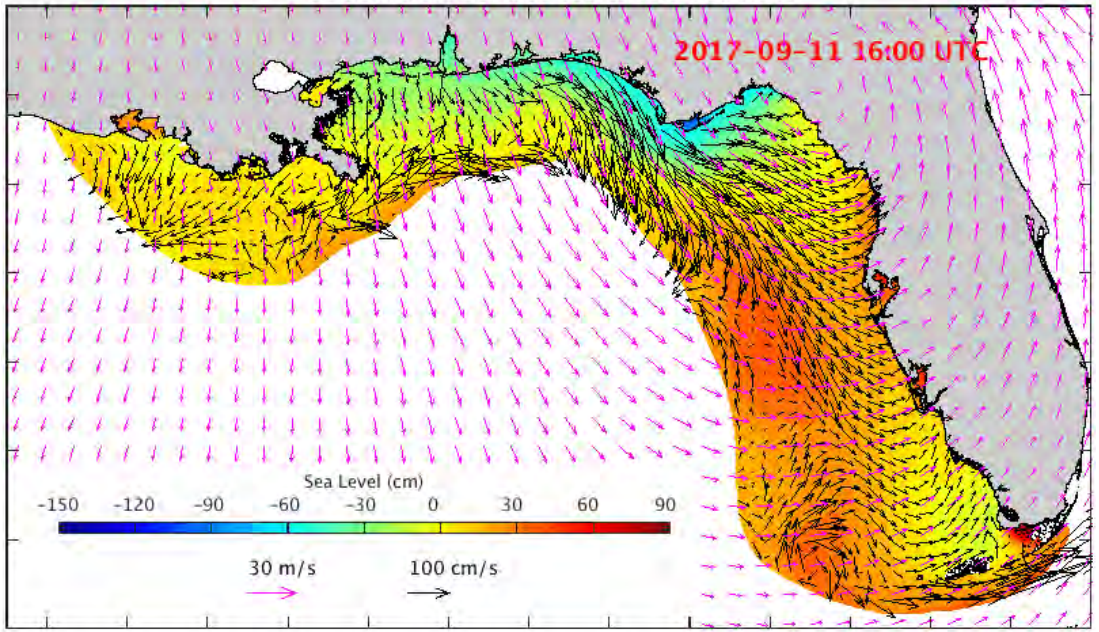


Surface Winds Overlain on WFCOM Simulated Surface Currents and Sea Level (09-11-2017)



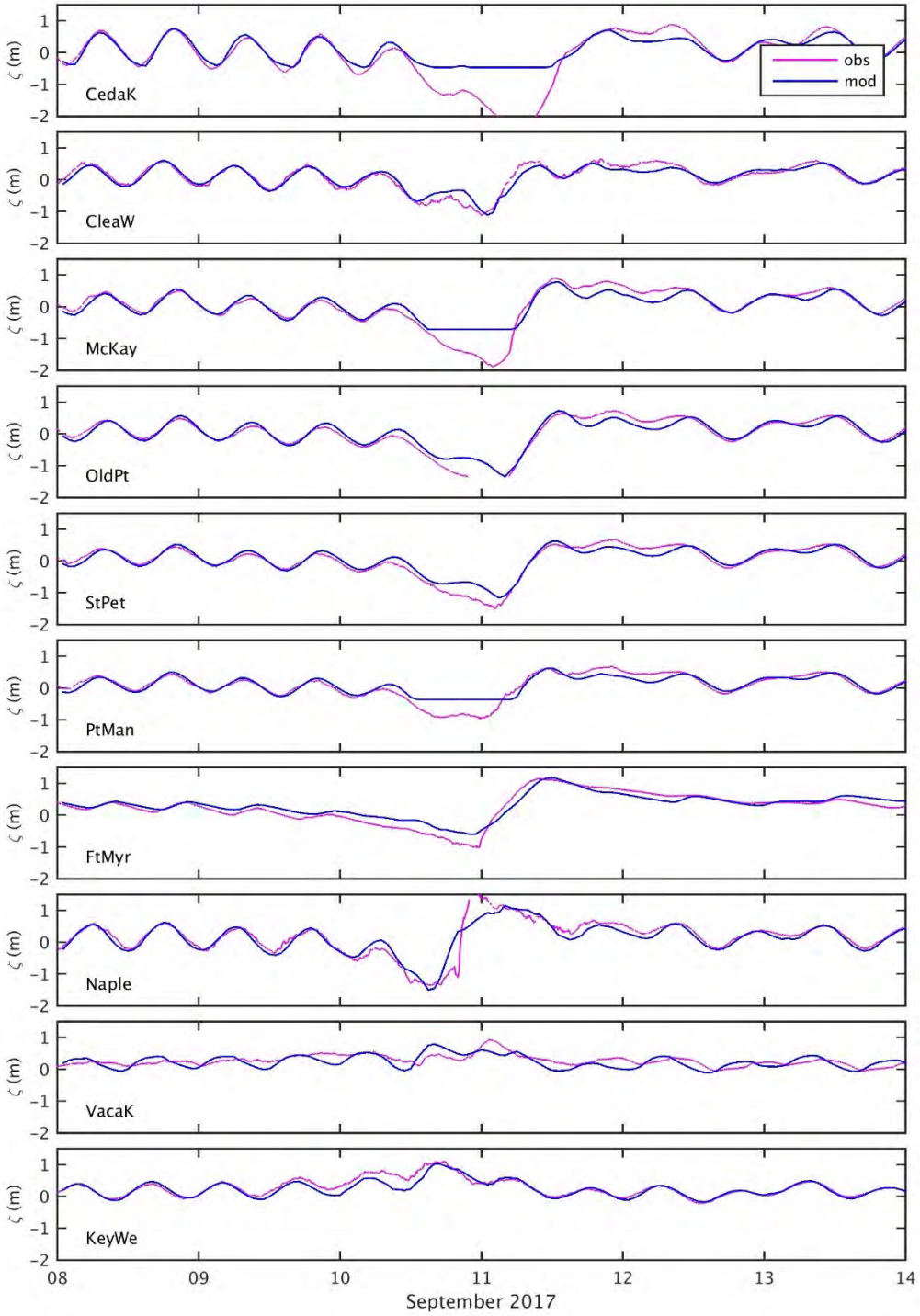


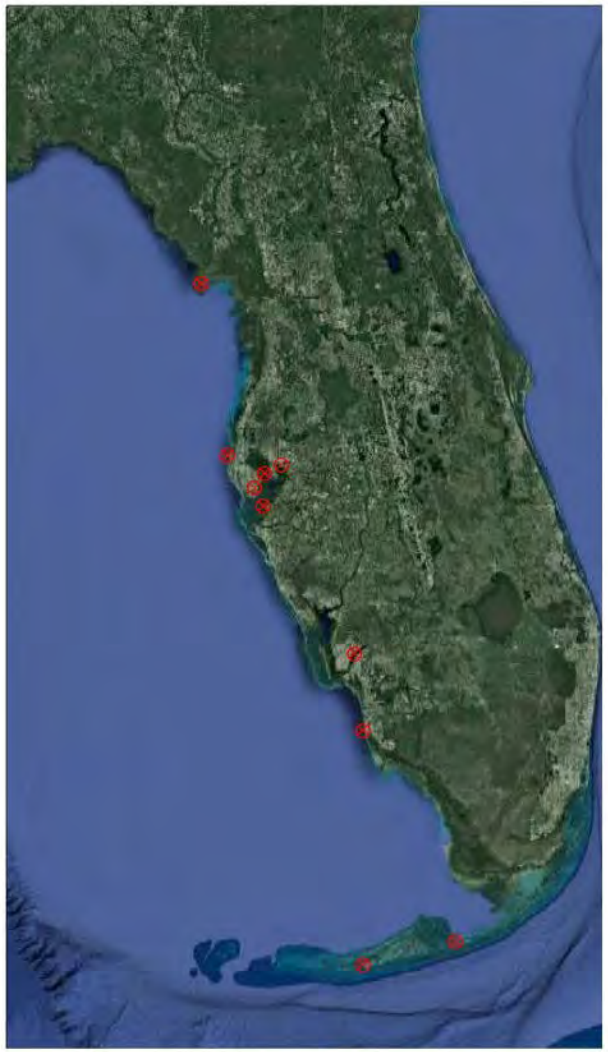




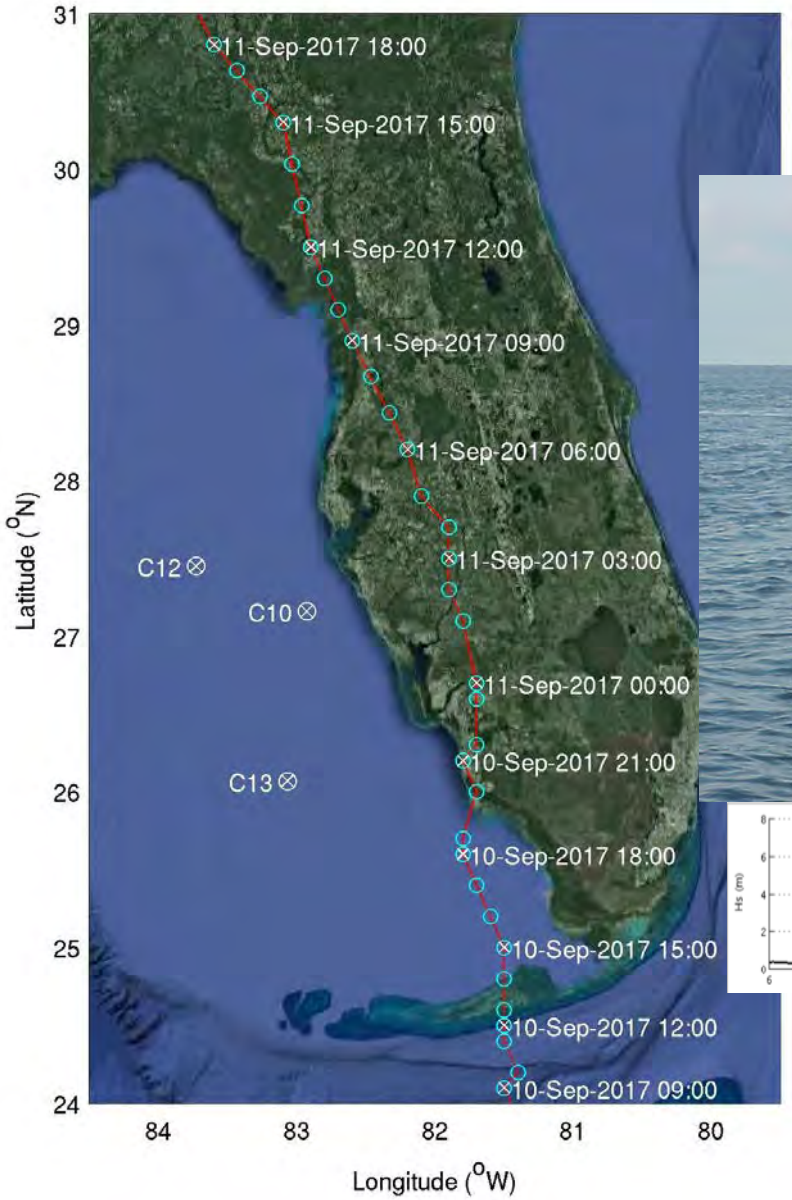
Observed vs. WFCOM Simulated Water Levels at Tide Gauges Along the West Florida Coast

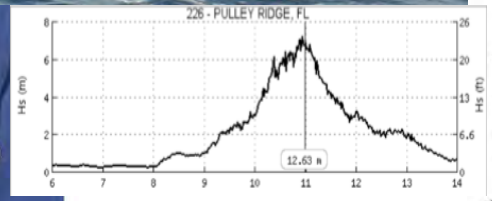
(from Key West to Cedar Key)



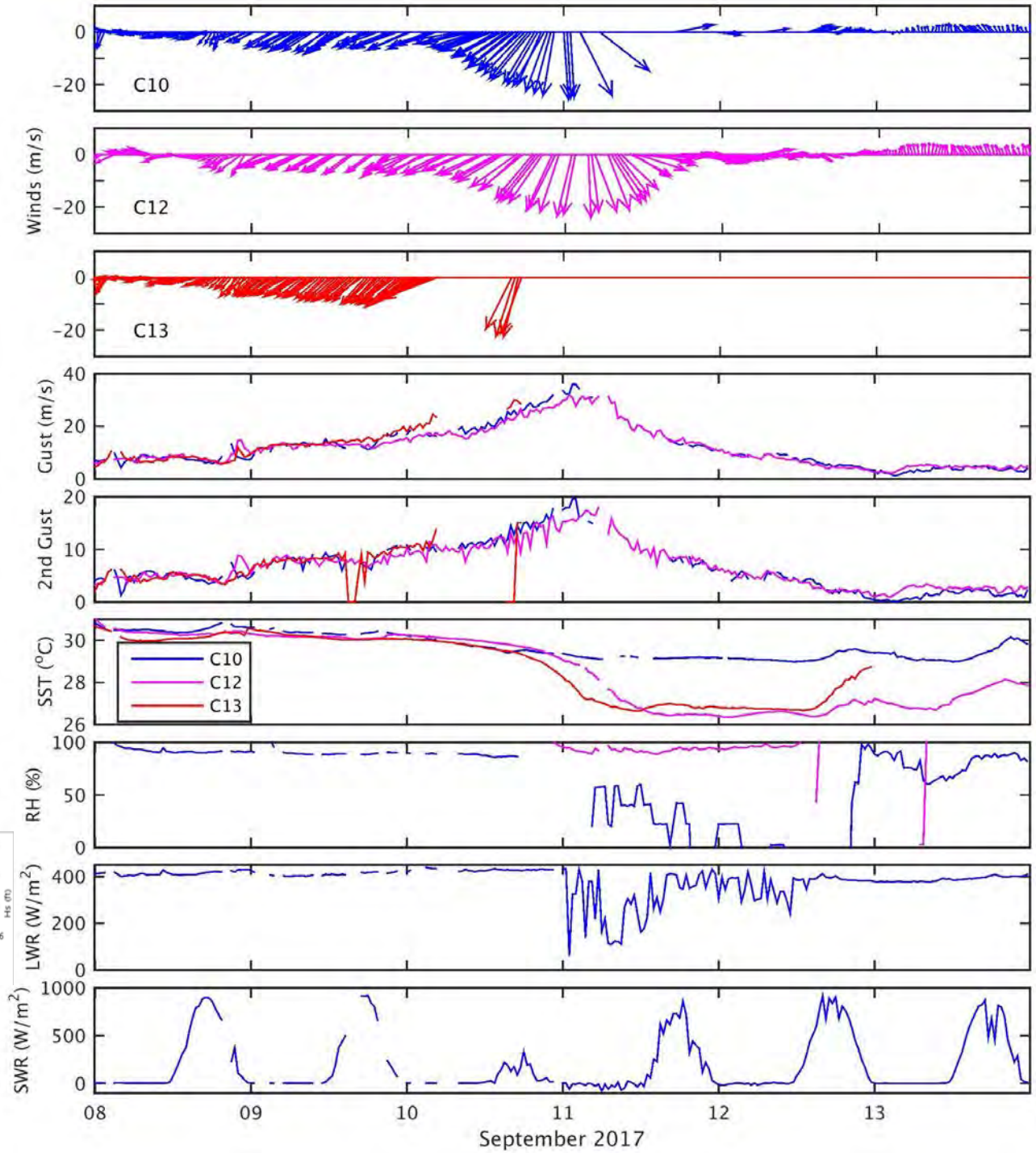


Meteorological Observations at the Three Moorings

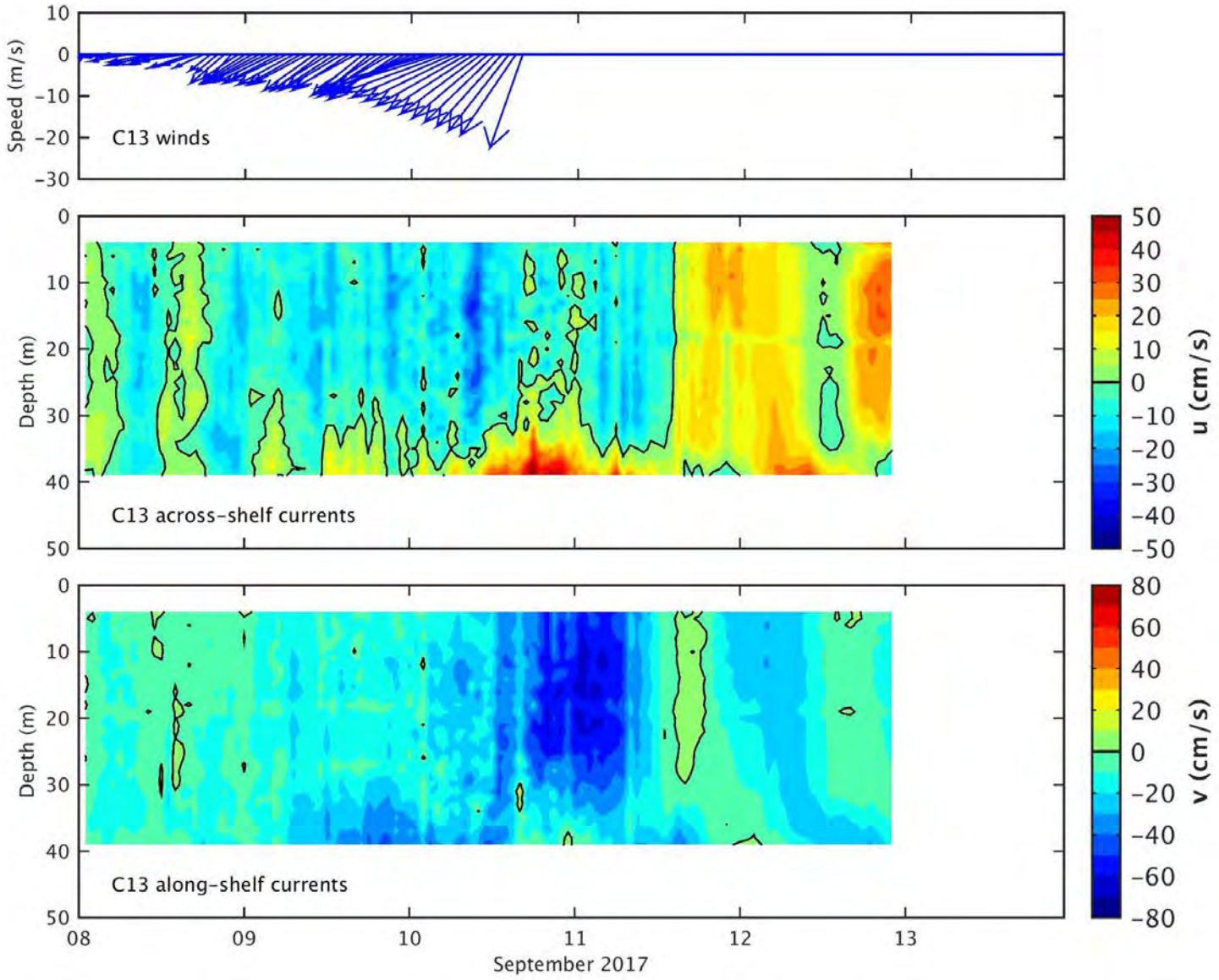


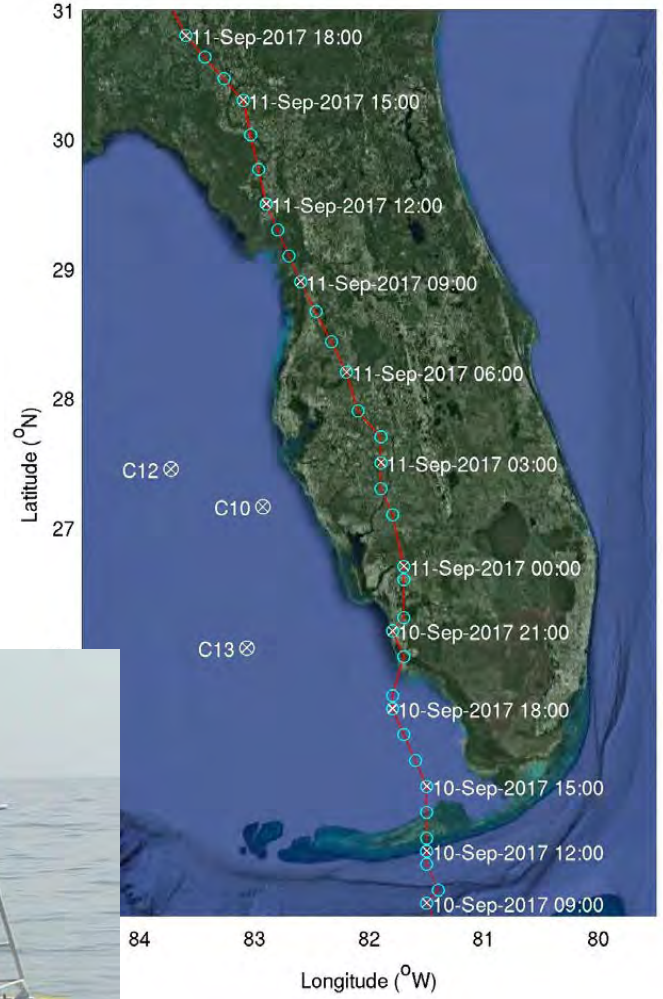


Wave data courtesy of CDIP, SIO; J. Behrens, J. Thomas

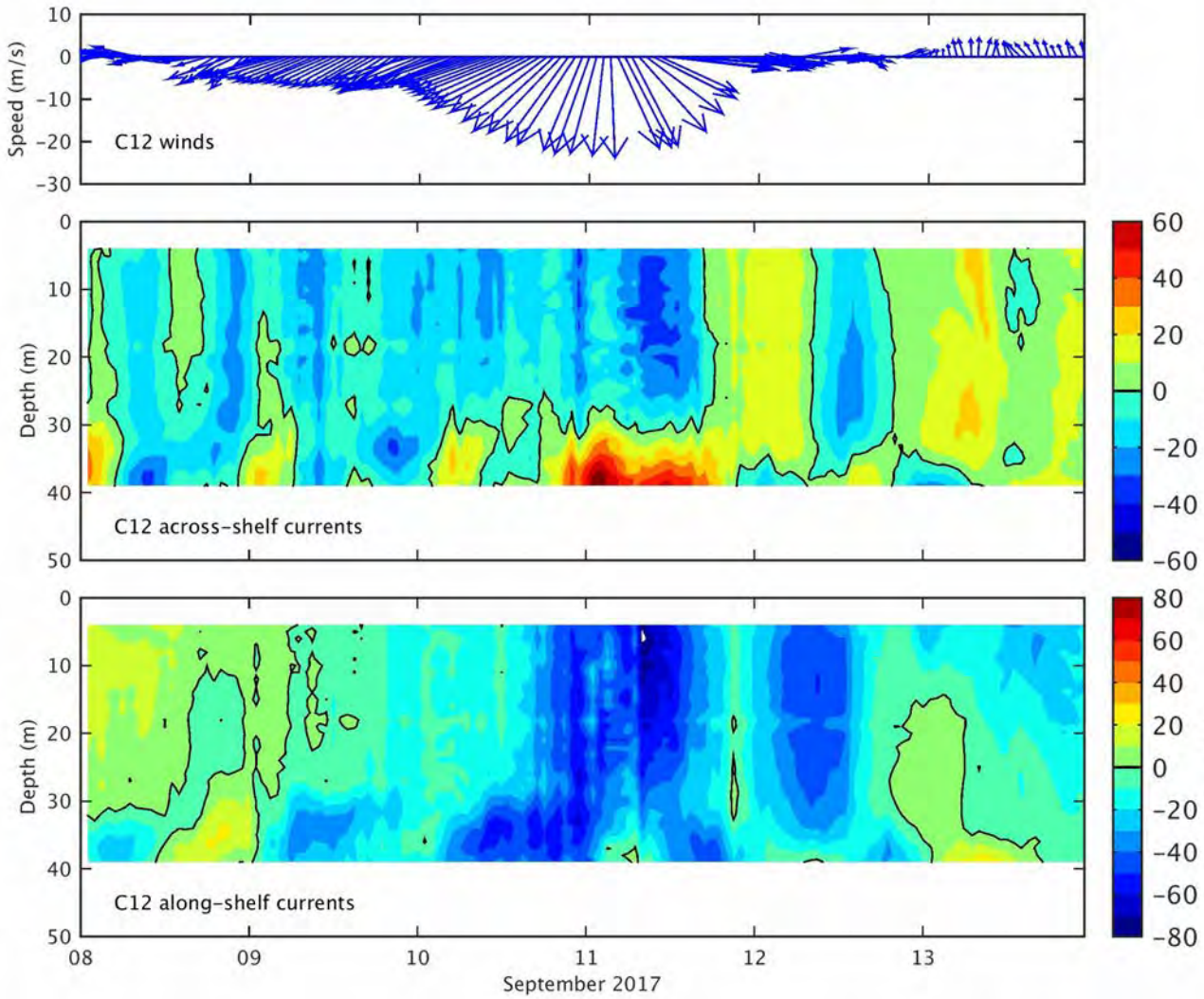


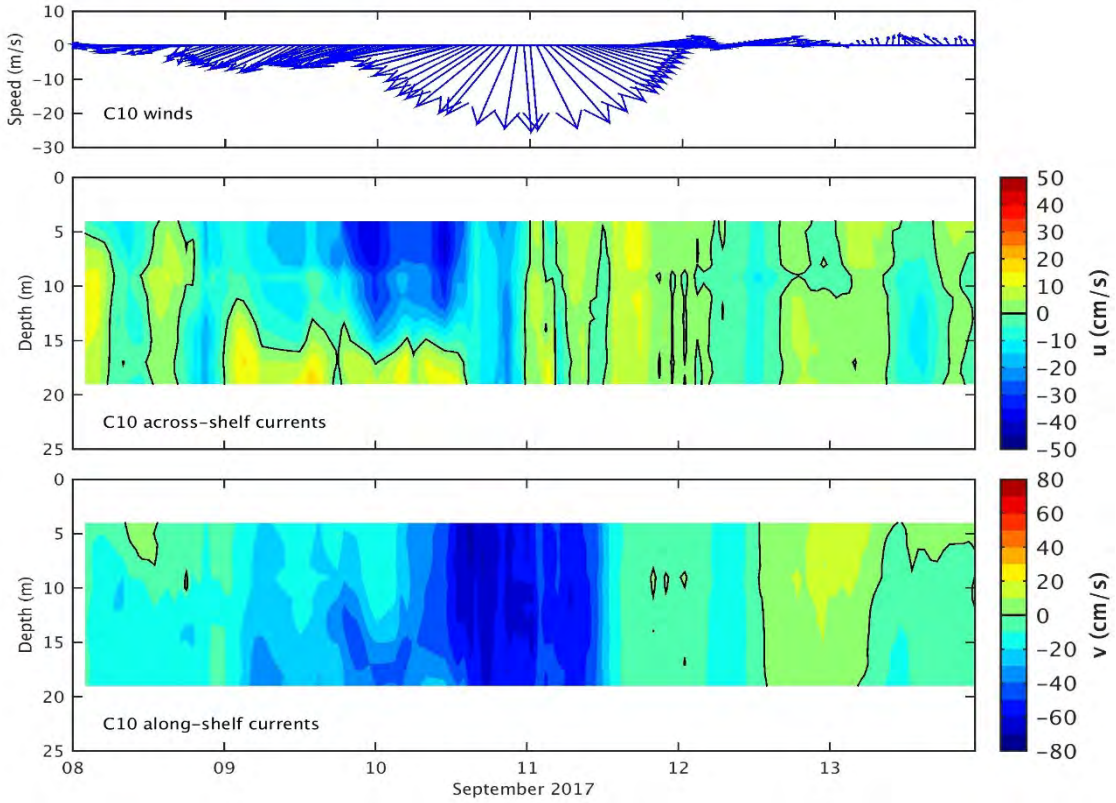
Observed Winds & Currents at Moorings C13





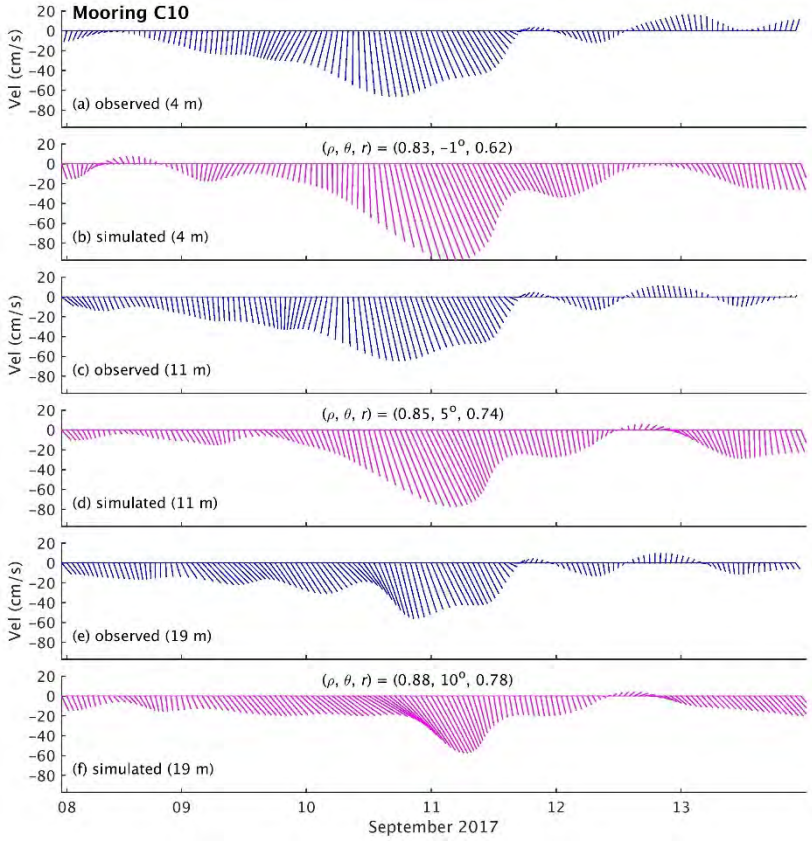
Observed Winds & Currents at Moorings C12 & C10

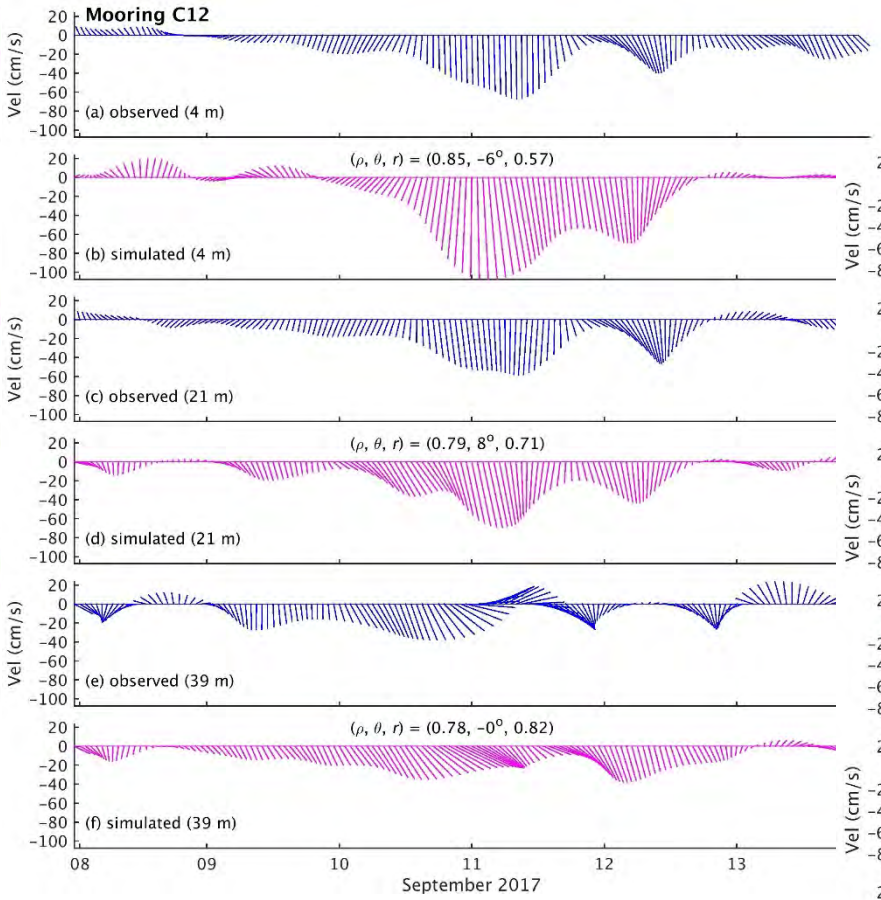


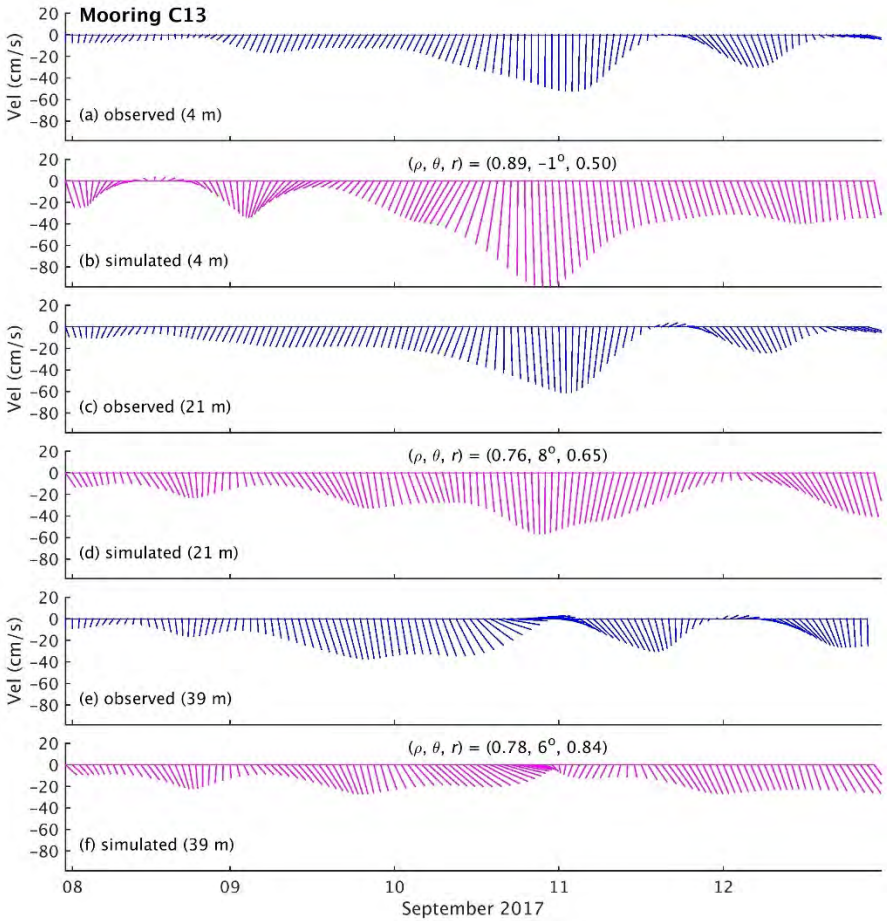


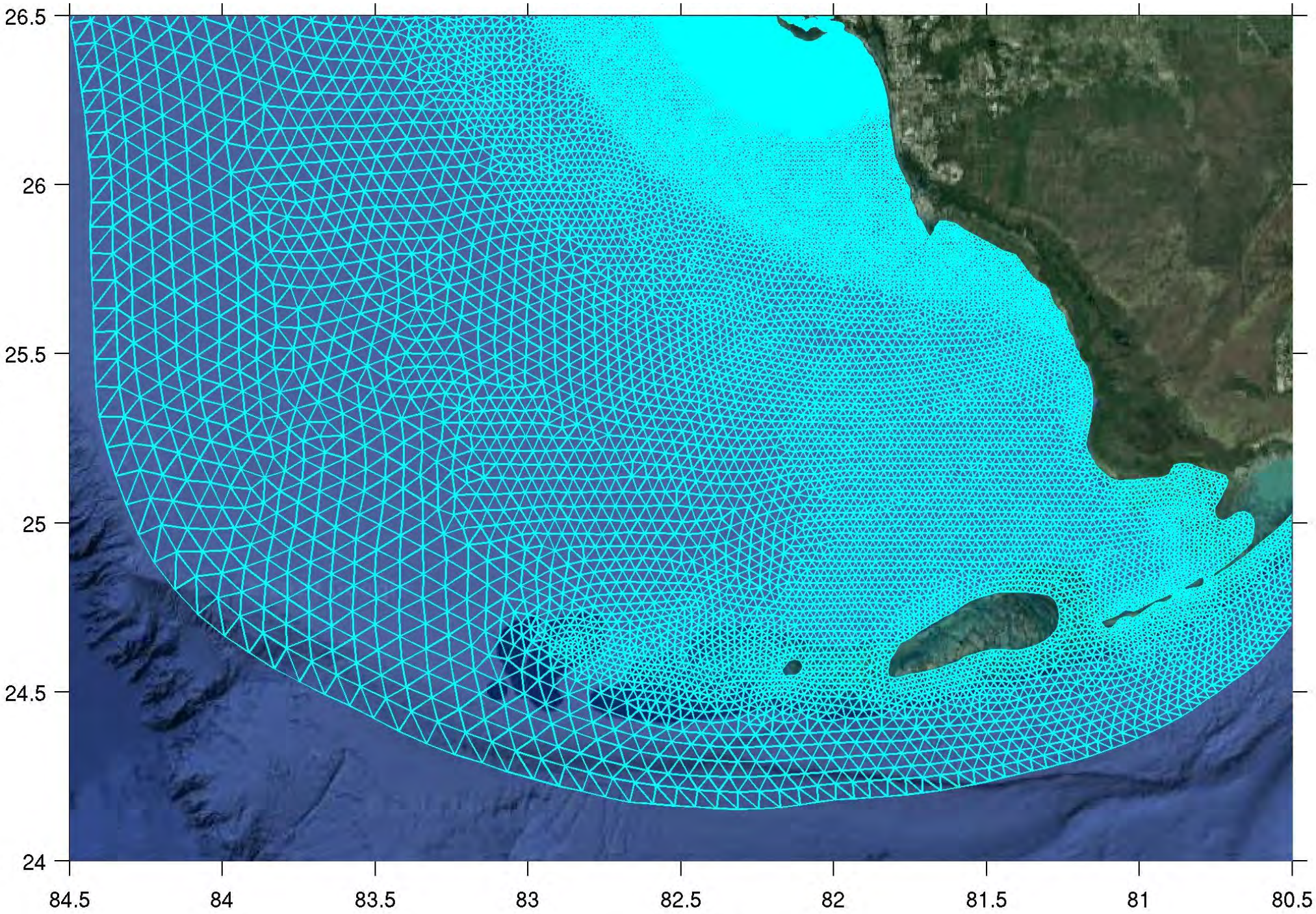
Observed vs. WFCOM Simulated Currents at Moorings C10, C12 and C13

Note: The simulated currents were larger than the observed currents because the simulated winds offshore were larger than the observed winds, which is opposite from what occurred near shore.









WFCOM grid within the Florida Bay region

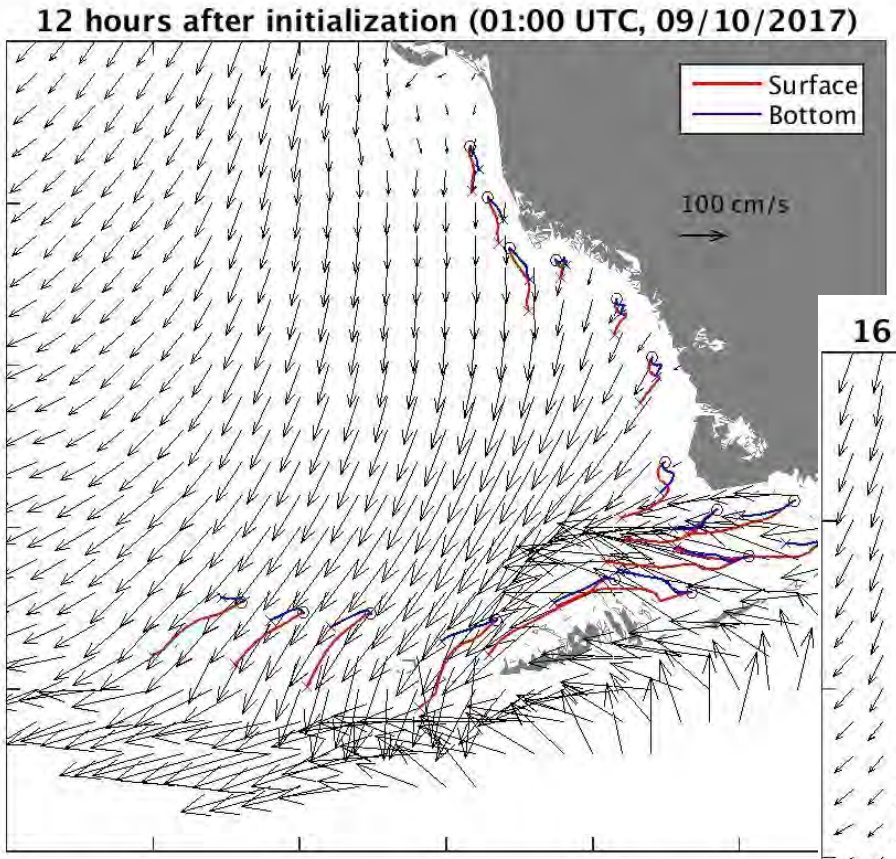
High resolution in the FL Keys passages!

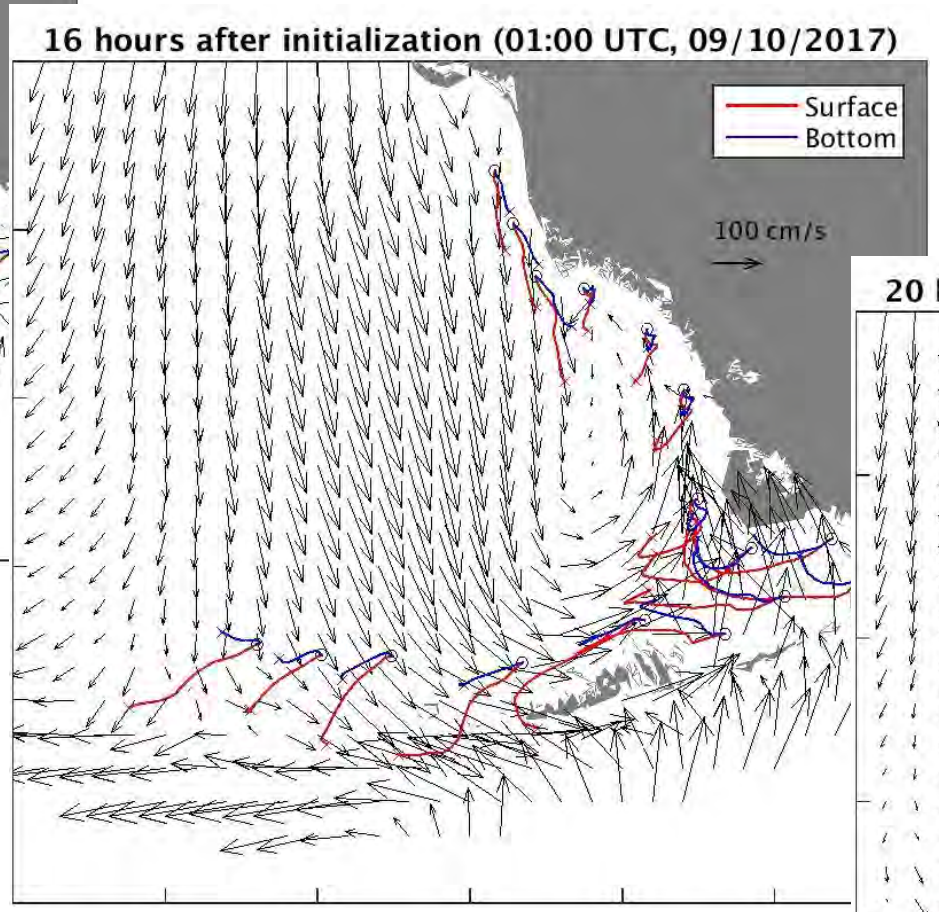
9-11-17

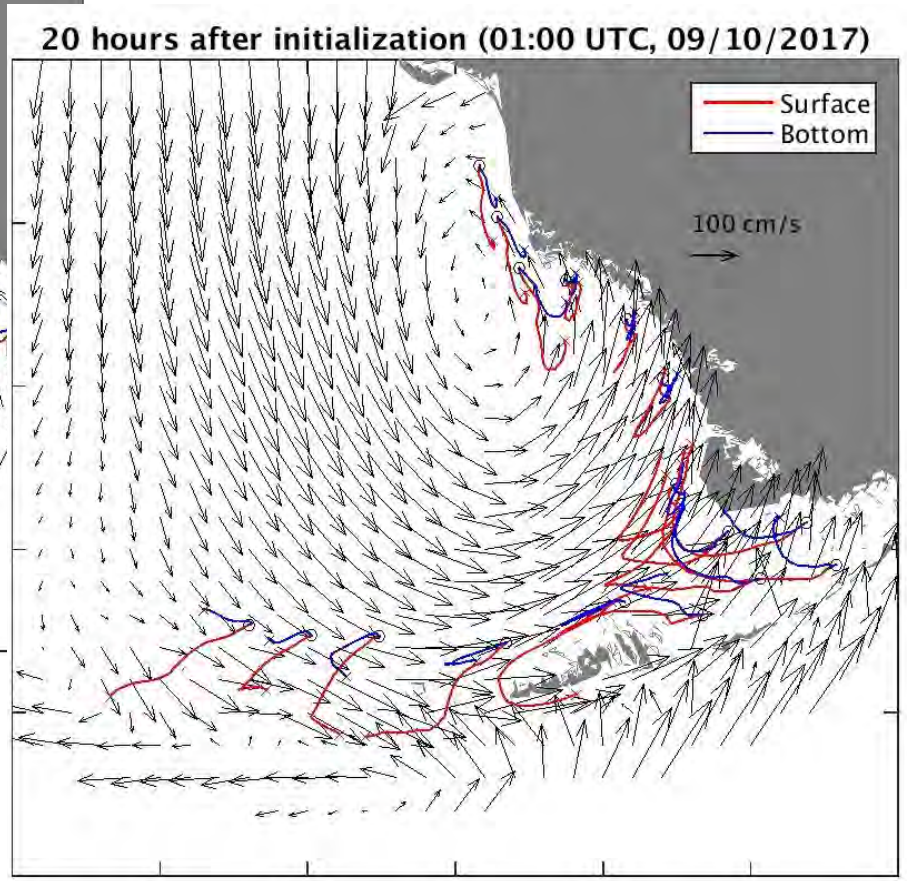
9-12-17

9-13-17

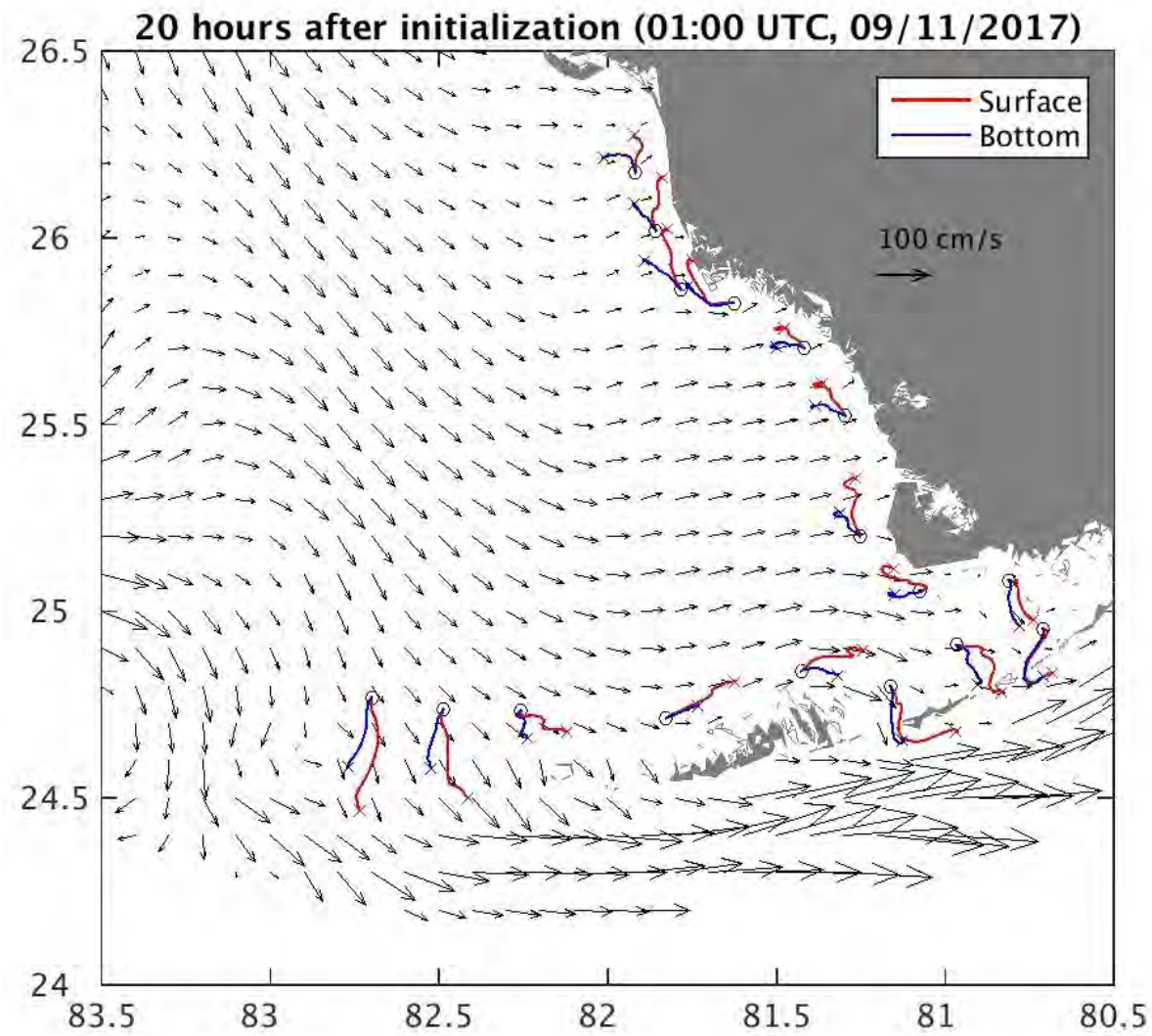
Lagrangian Drifter Trajectory Simulations for Particles Released Along the Florida Bay Coast During Hurricane Irma on 09-10-2017

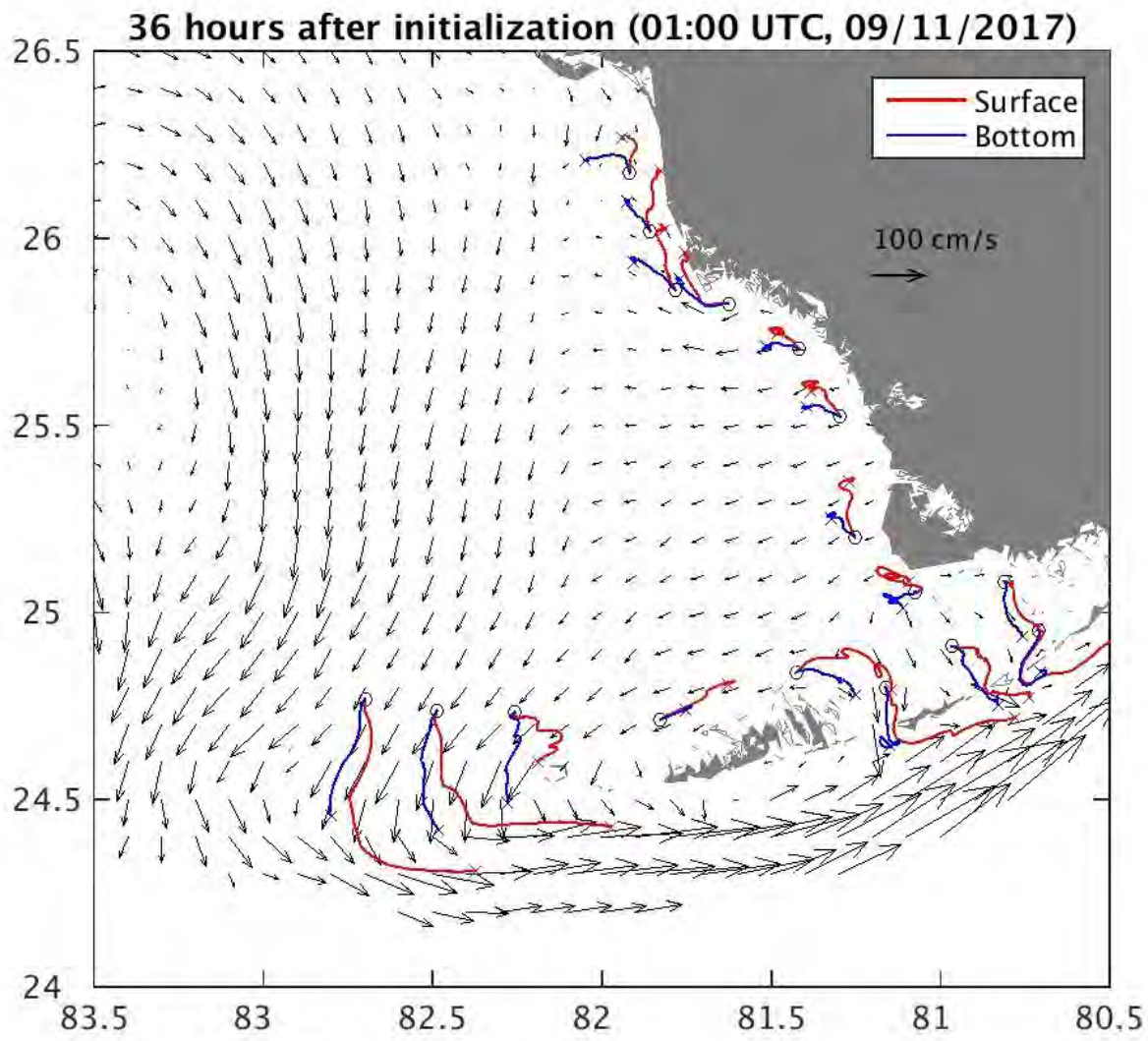




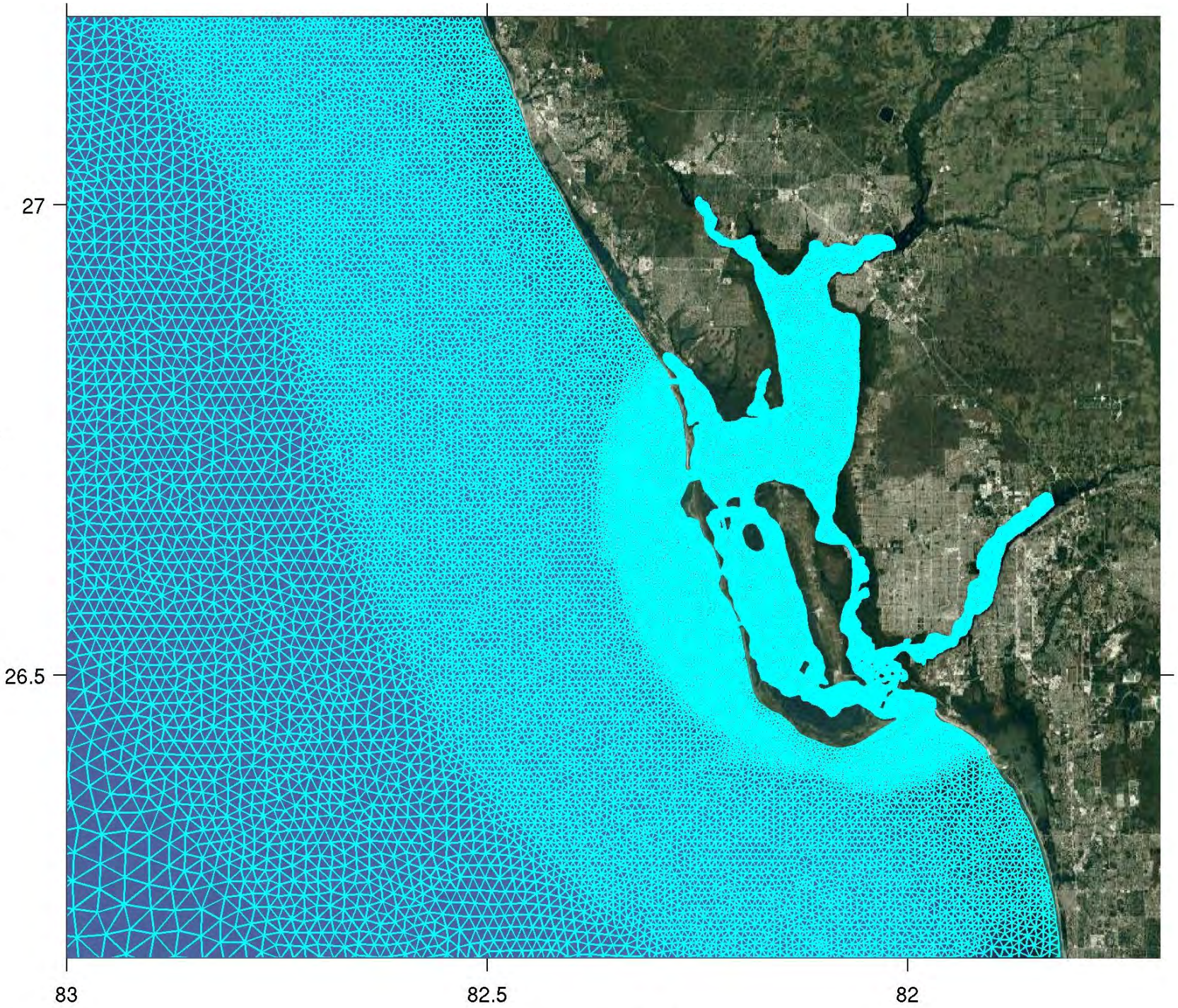


Lagrangian Drifter Trajectory Simulations for Particles Released Along the Florida Bay Coast after the Passage of Hurricane Irma on 09-11-2017.





Note the movement of drifters around the Dry Tortugas and through the Florida Keys passages, accounting for the sediment transport over the reef track as observed in satellite imagery.

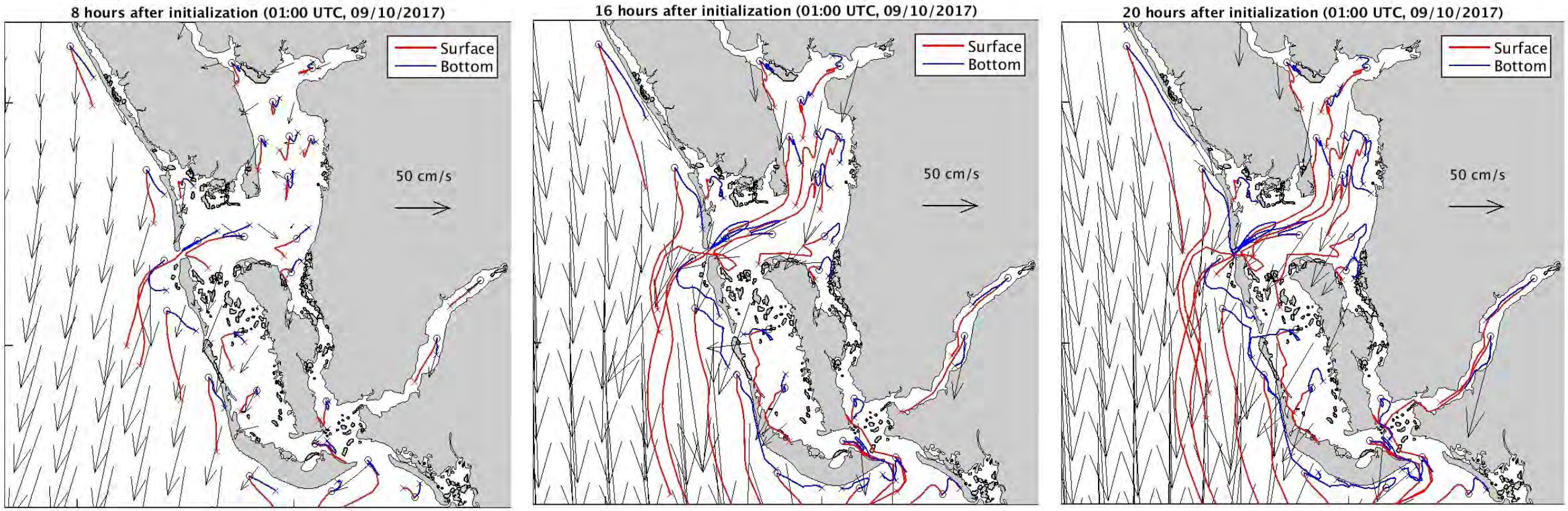


WFCOM Grid within the Charlotte Harbor Region

Note that the Charlotte Harbor estuary is highly resolved.

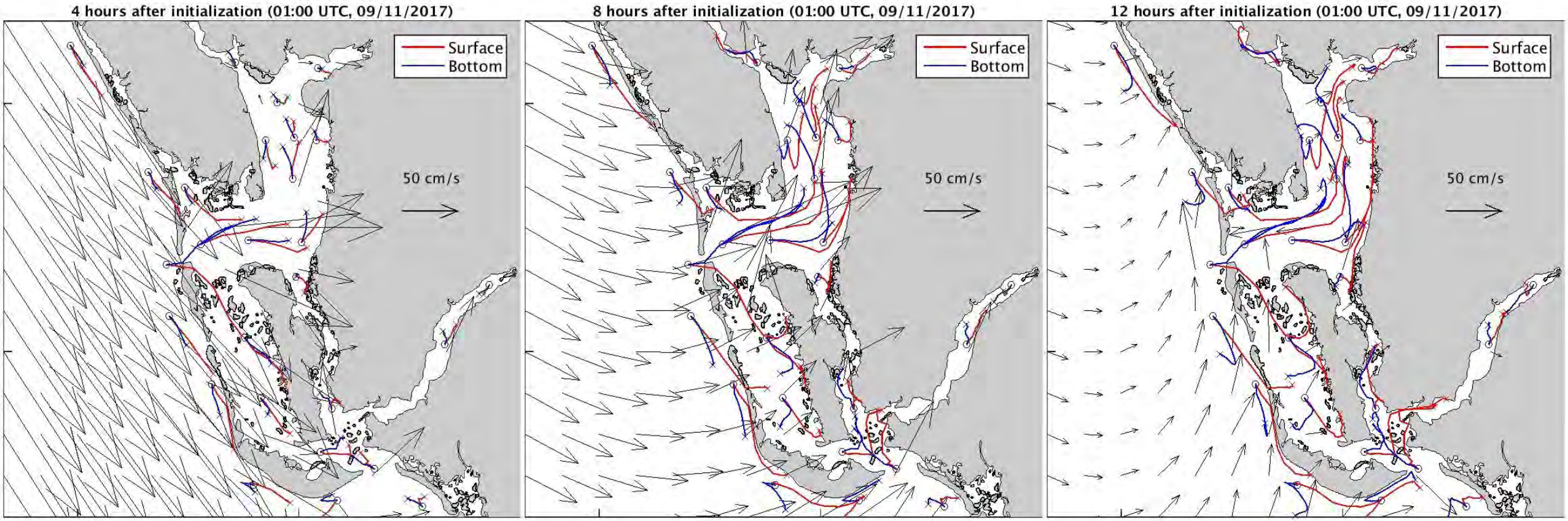
Lagrangian Drifter Trajectories for the Charlotte Harbor Estuary Region During Hurricane Irma on 9-10-2017

Note that water surged out of the estuary taking with it anything (sediments, larvae, nutrients etc.) that was contained in these estuarine waters.

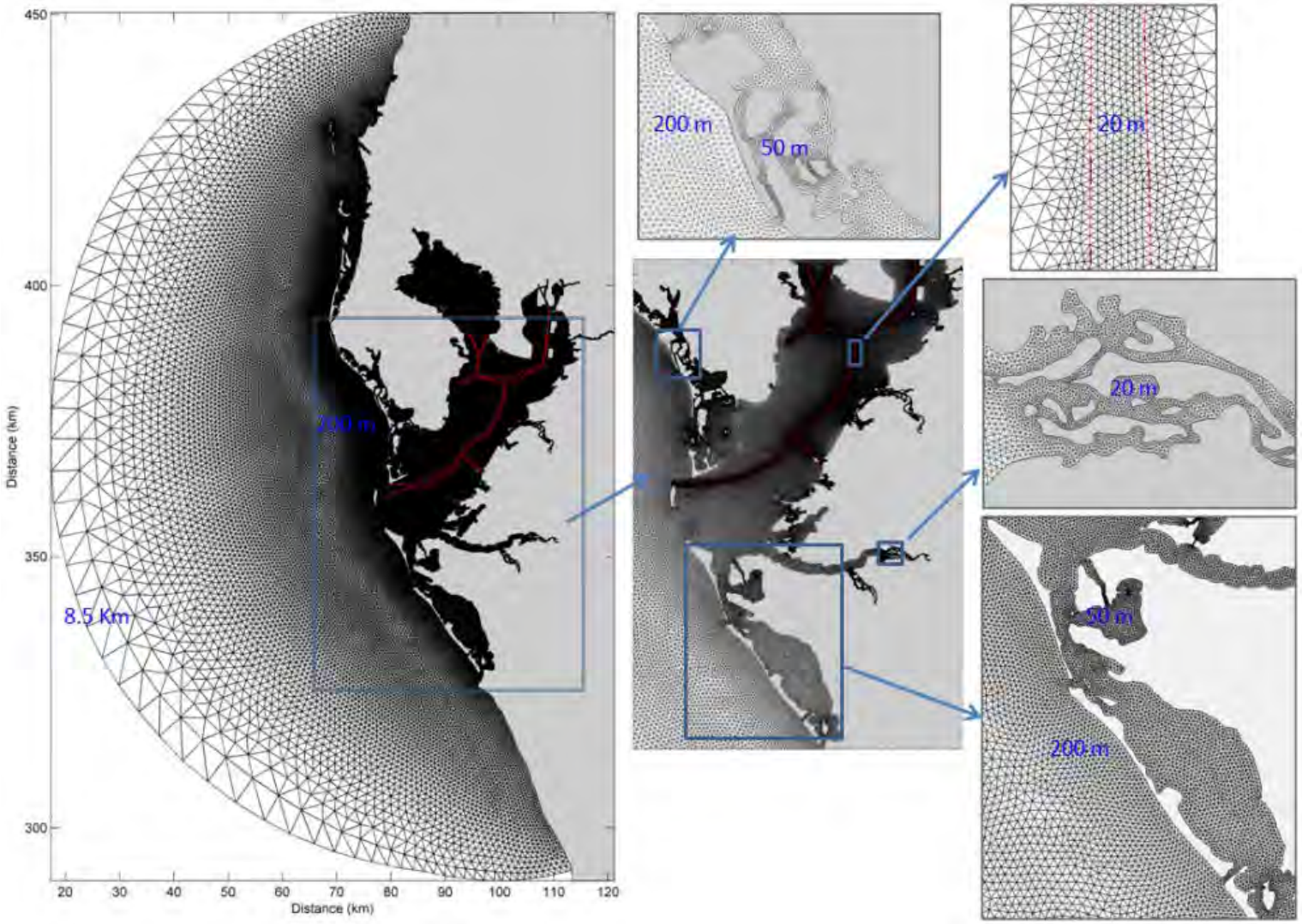


Lagrangian Drifter Trajectories for the Charlotte Harbor Estuary Region During Hurricane Irma on 9-11-2017

Note that water flooded back into the estuary after the passage of Irma, but that this was new water originating to the north. Thus Irma was a major flushing event with substantial ecological ramifications.



A New Tampa Bay Coastal Ocean Model (TBCOM) consisting of FVCOM nested in WFCOM provides higher resolution. Instead of the 100m-300 m resolution in WFCOM, TBCOM resolves as finely as 20 m. Thus TBCOM includes Tampa Bay, Sarasota Bay, the Intracoastal Waterway and all of the inlets connecting these with themselves and with the adjacent Gulf of Mexico

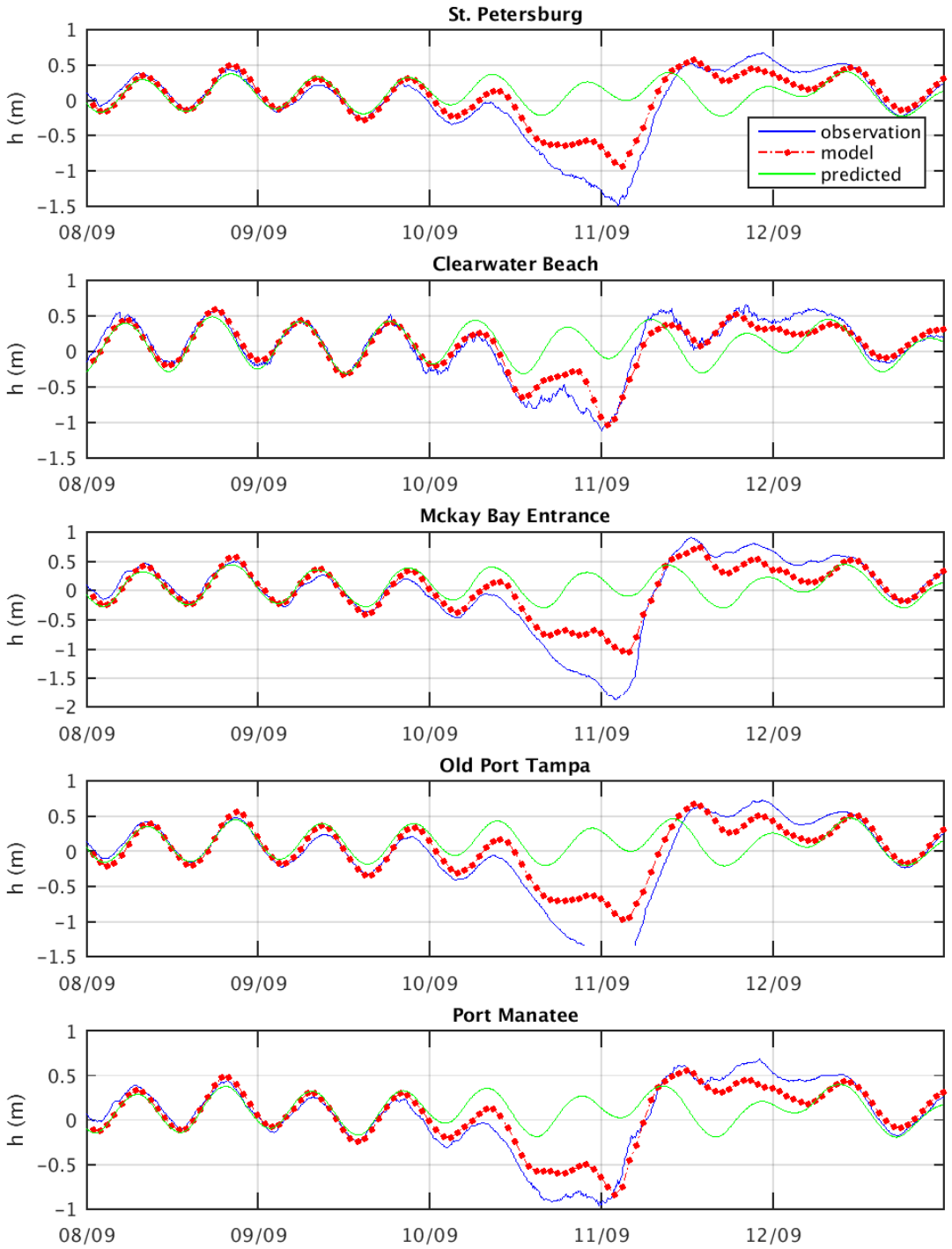


TBCOM Performance for Hurricane Irma: Sea Level Comparisons

From top to bottom are comparisons between sea levels predicted by tides, observed and modeled for stations at St. Petersburg, Clearwater Beach, Mackay Bay, Old Port Tampa and Port Manatee (all relative to mean sea level).

Note that as with Charlotte Harbor there was an initial negative surge followed by a rapid rise in sea level as Irma passed to the north.

Our initial simulation underestimated the negative surge, but as shown next this was due to underestimated winds used to force the model.

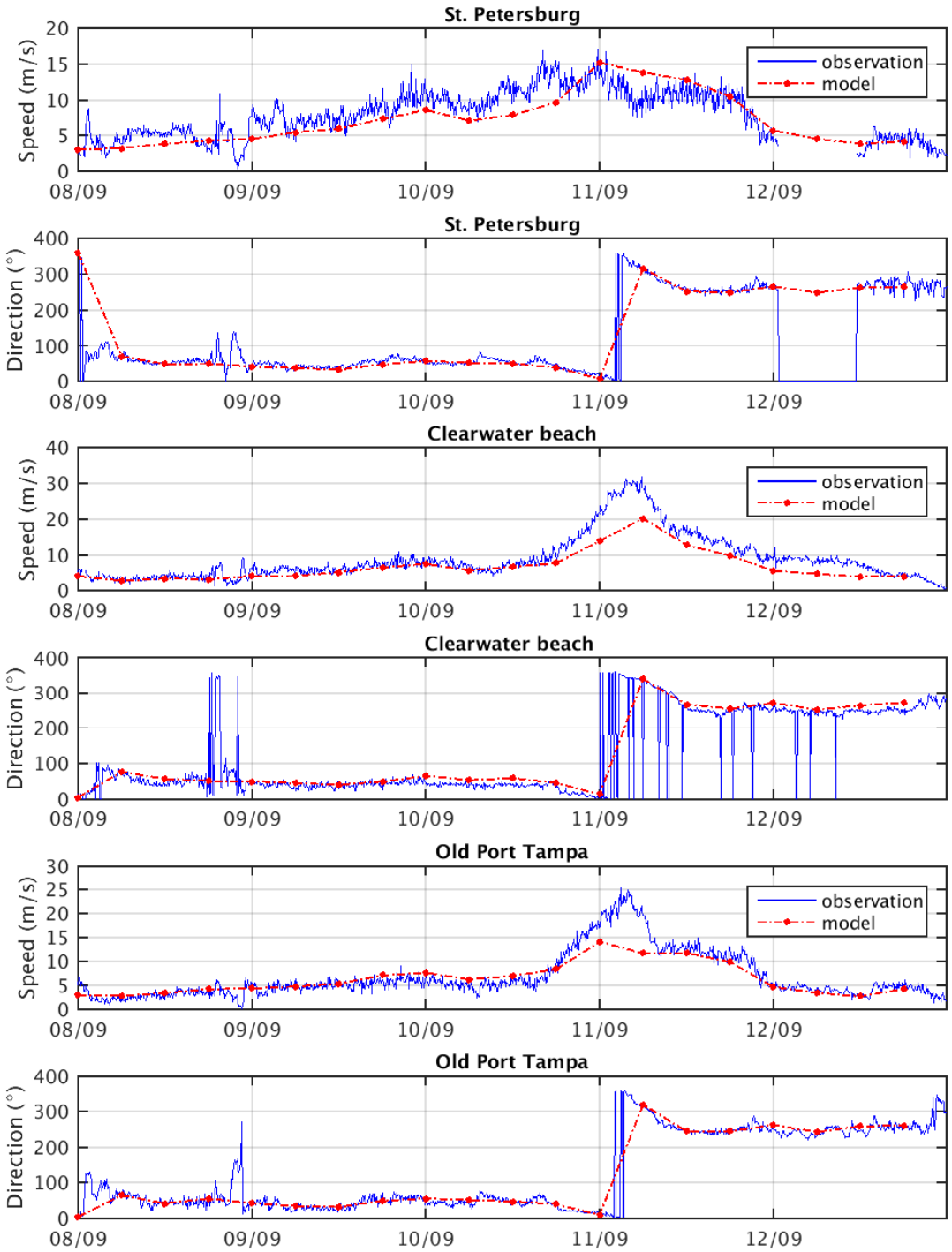


Hurricane Irma Wind Comparisons

From top to bottom are comparisons between wind speeds and directions observed and modeled (by NOAA) for stations at St. Petersburg, Clearwater Beach and Old Port Tampa.

Note that the NOAA modeled wind speeds used to force the Tampa Bay circulation model underestimated the observed winds during Irma by a factor of about 1.6. This, plus the six hourly sampling of the winds, reduced and smoothed the circulation model response.

Let's now see what happens when we adjust the winds.



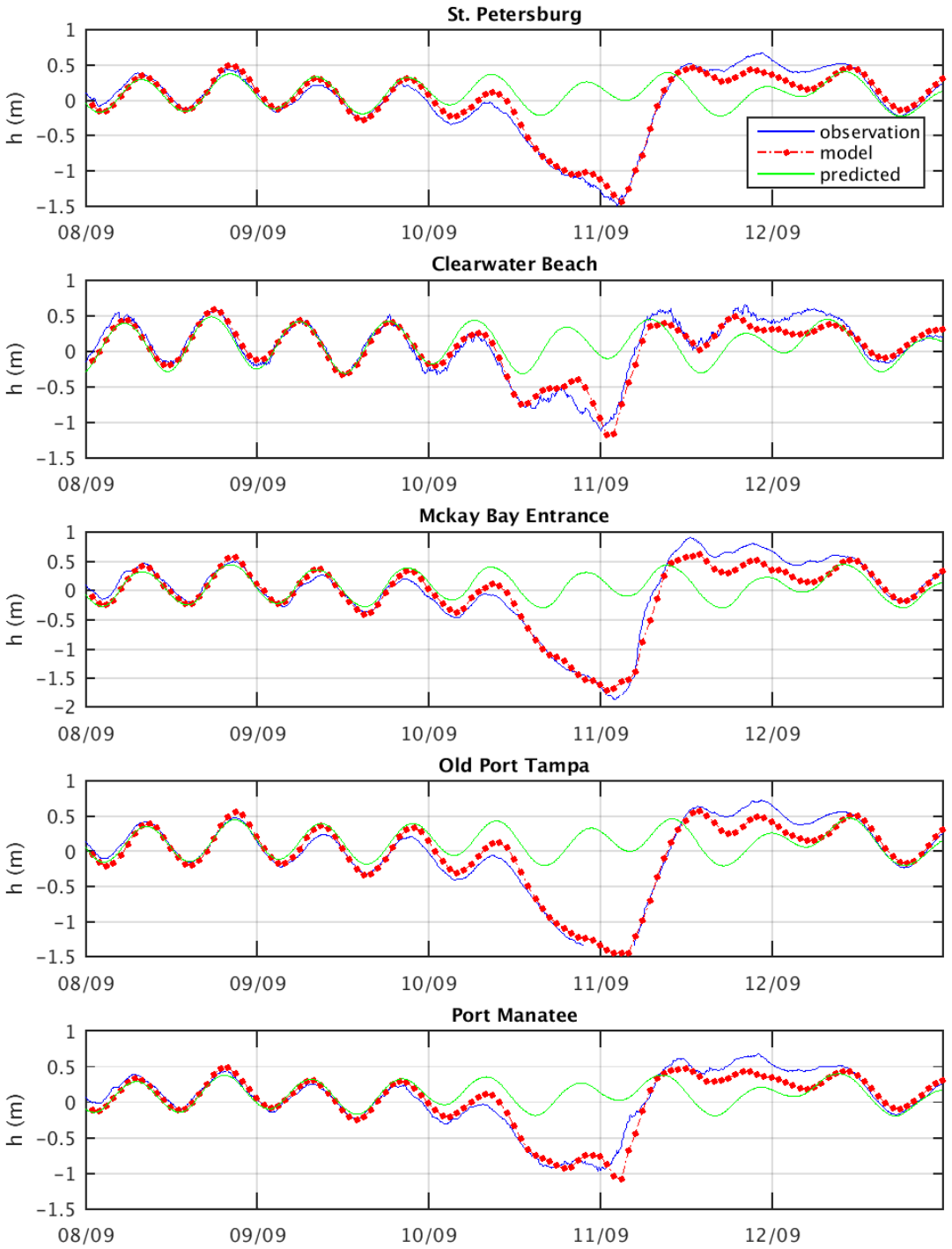
Hurricane Irma Sea Level Comparisons with wind speed increased by a factor of 1.6

From top to bottom are comparisons between sea levels predicted by tides, observed and modeled for stations at St. Petersburg, Clearwater Beach, Mackay Bay, Old Port Tampa and Port Manatee (all relative to mean sea level).

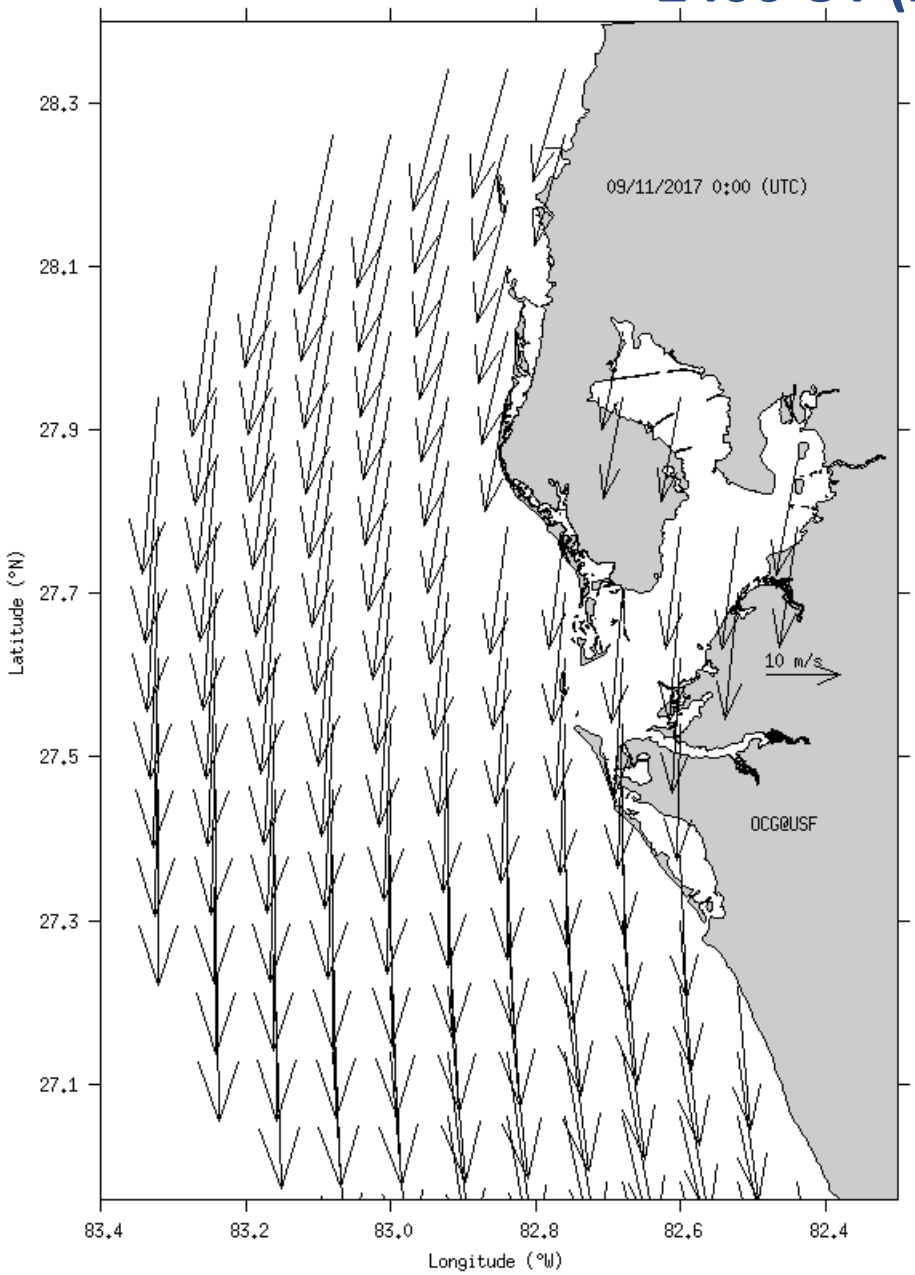
The sea level simulations are now in much better agreement with the observations.

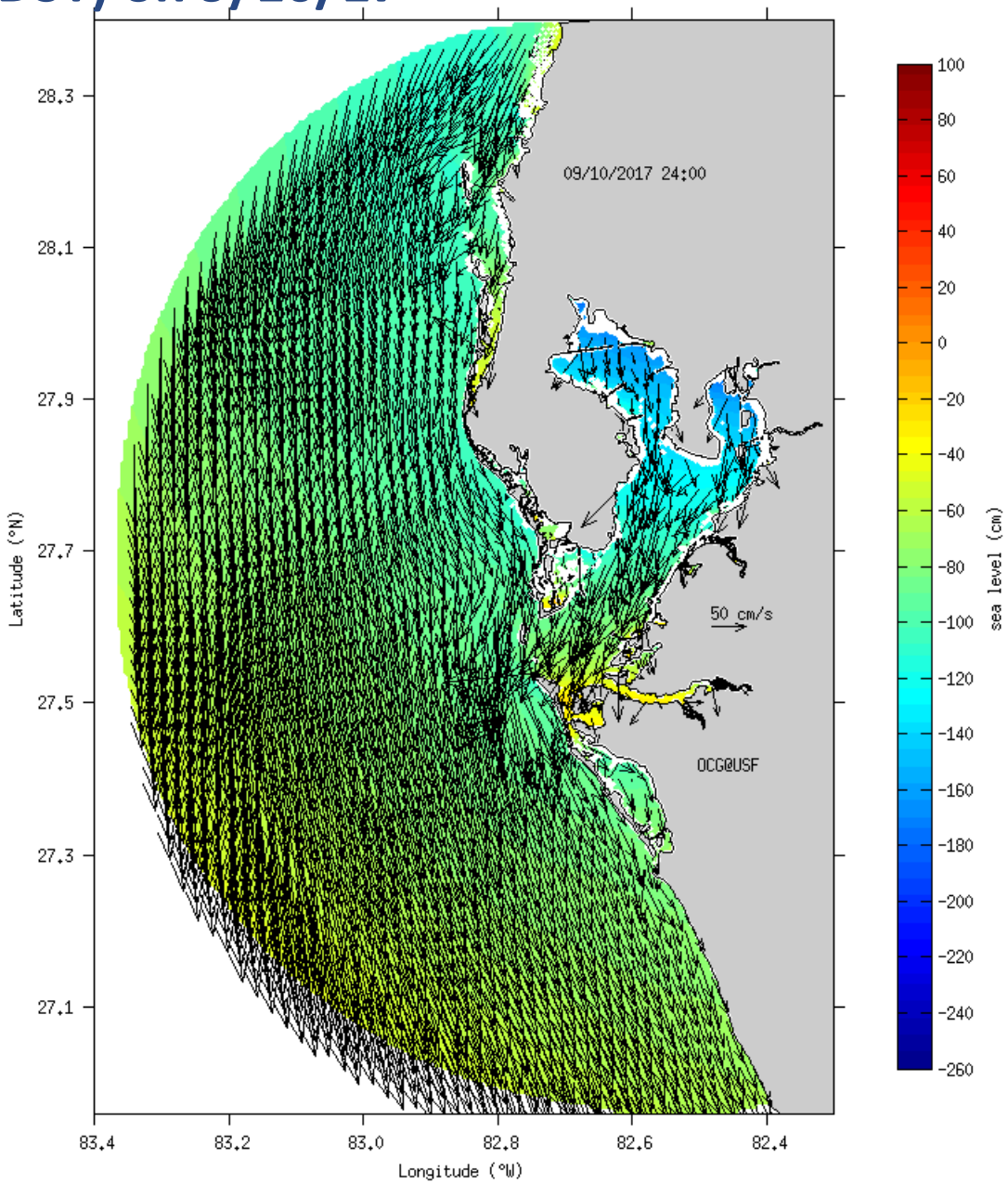
The lesson is that: modeling the coastal ocean response to winds requires more accurate winds. This can only be achieved if there are enough coastal ocean wind observations to assimilate into the weather forecast models.

This lesson is a major justification for IOOS. Ecology depends on the circulation; the circulation depends on winds. Models depend on data!!!

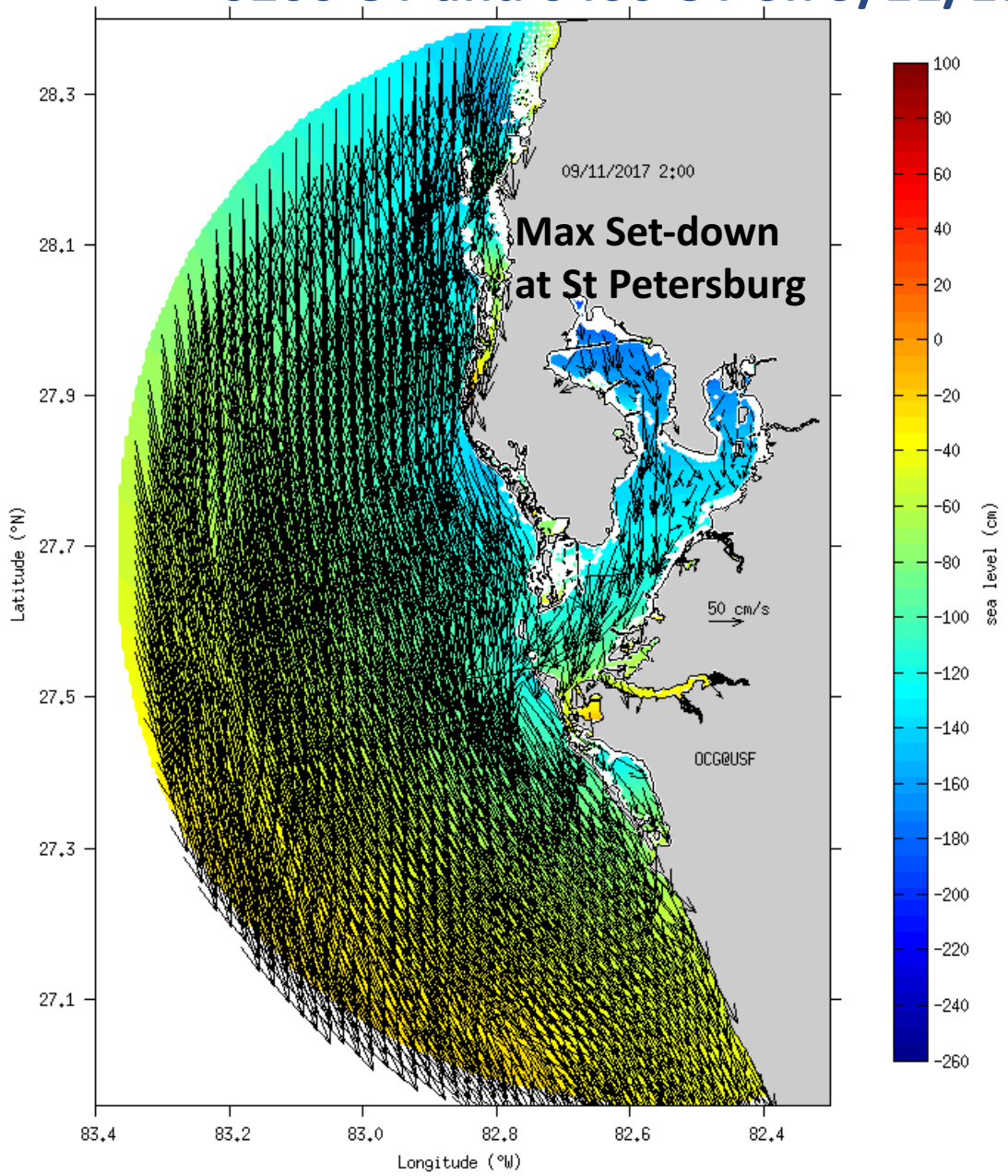


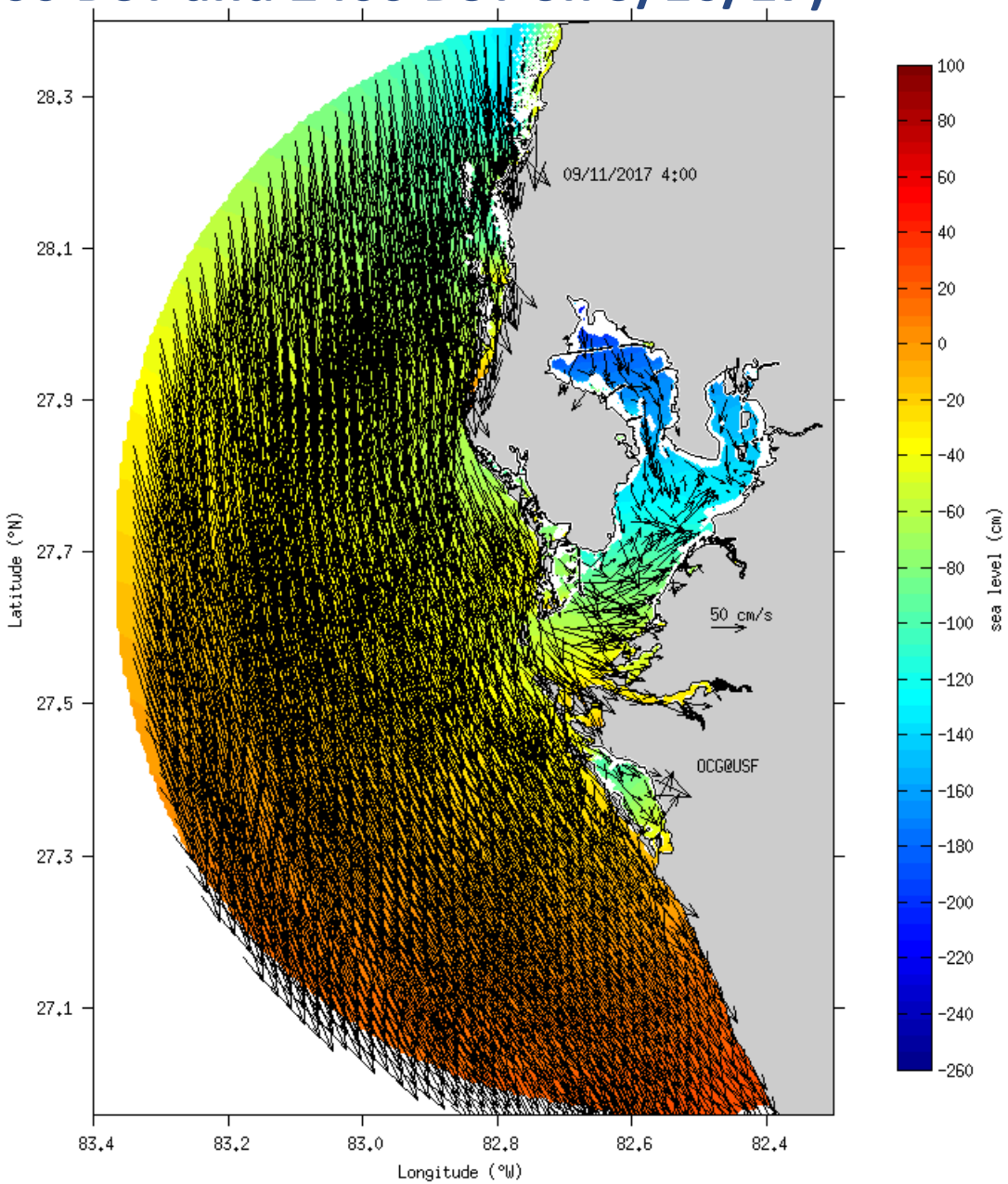
Tampa Bay Model Domain Winds, Surface Currents and Sea Level
2400 UT (2000 DST) on 9/10/17



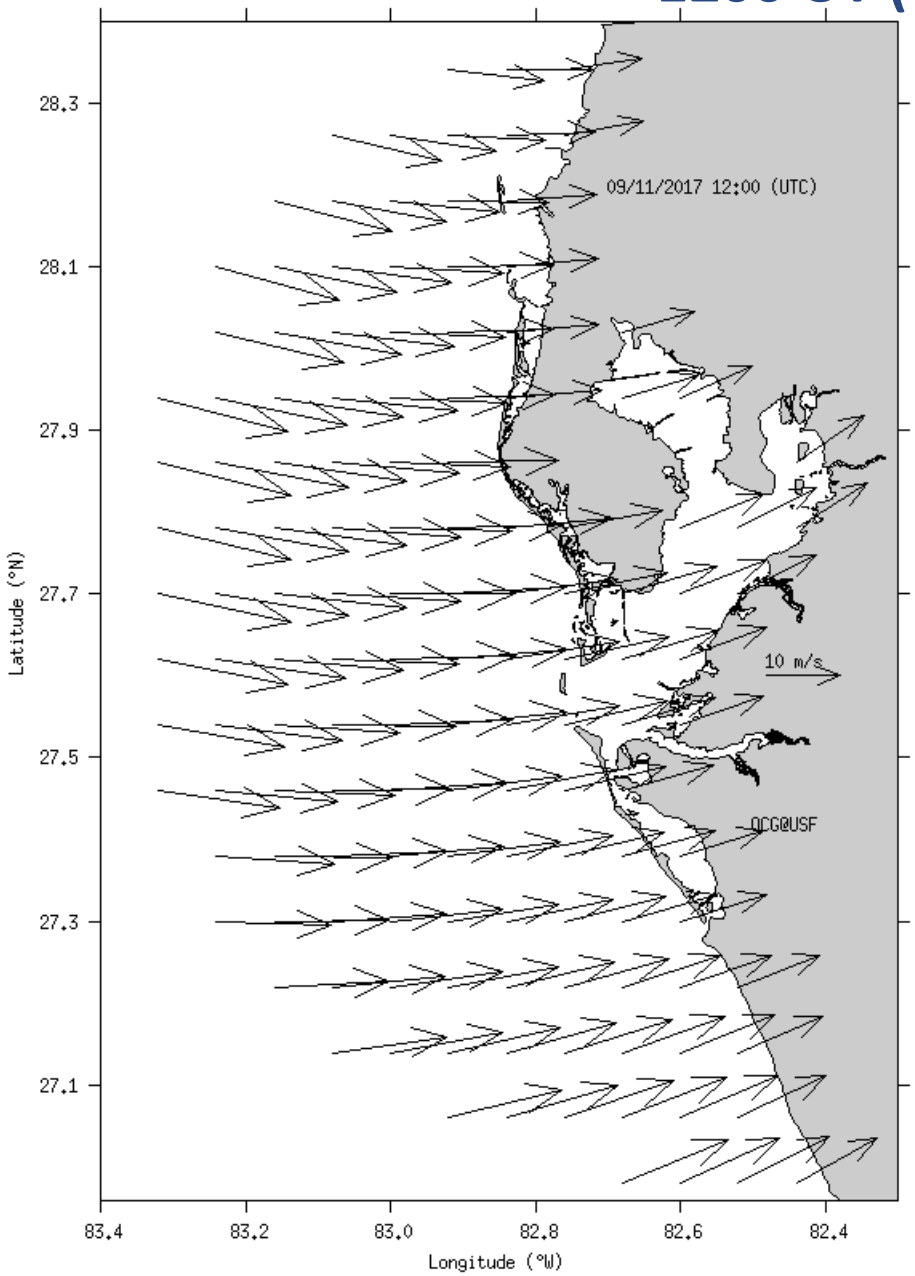


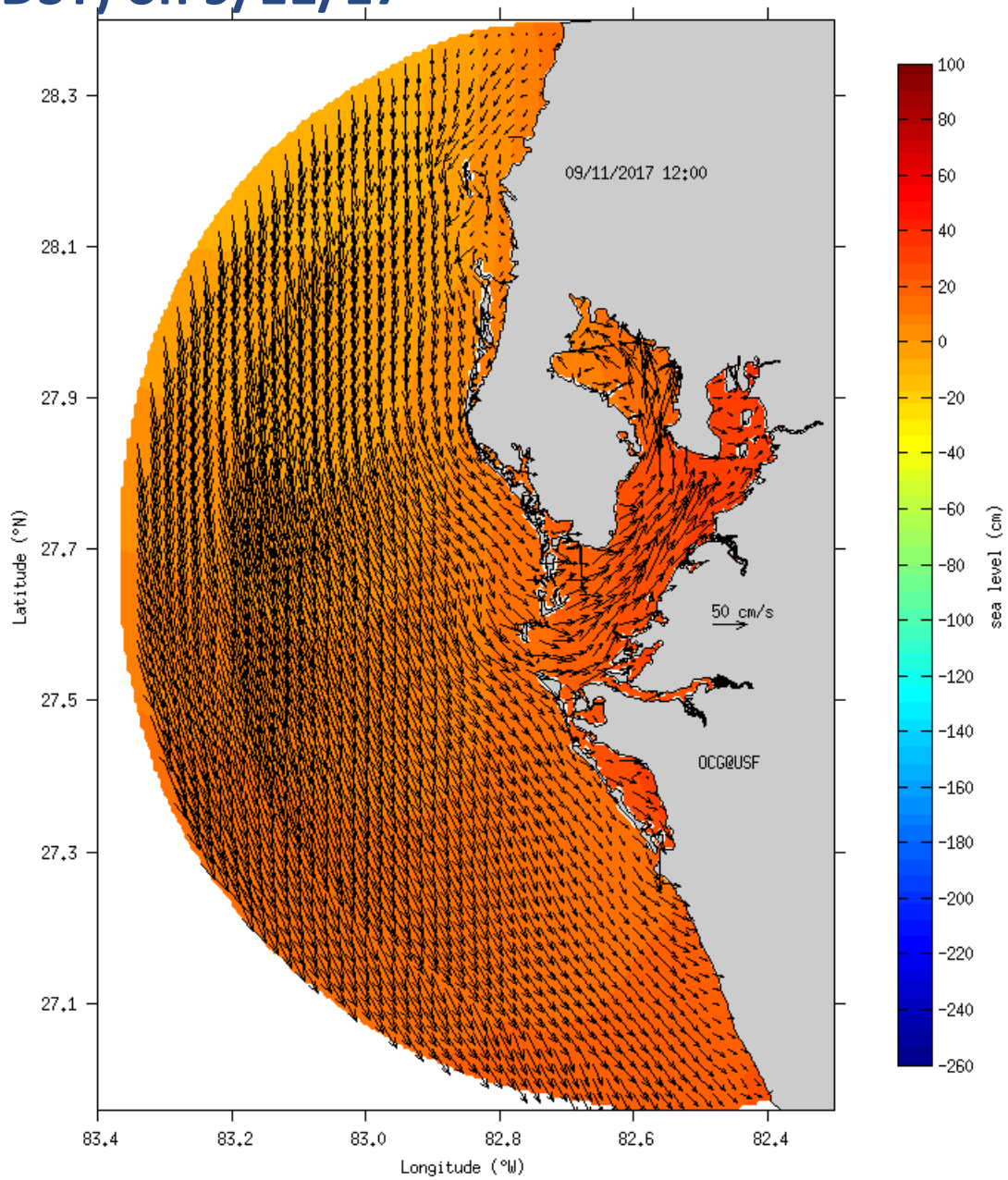
Tampa Bay Model Domain Surface Currents and Sea Level
0200 UT and 0400 UT on 9/11/17 (2200 DST and 2400 DST on 9/10/17)





Tampa Bay Model Domain Winds, Surface Currents and Sea Level
1200 UT (0800 DST) on 9/11/17

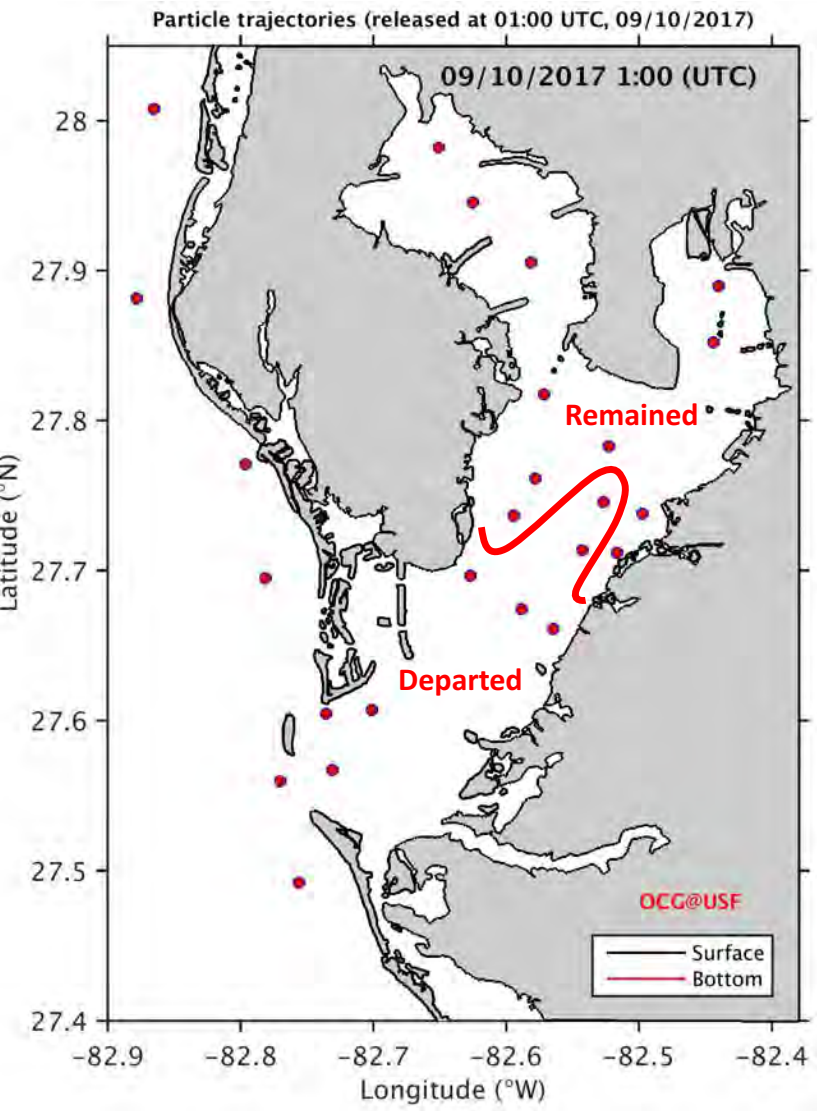


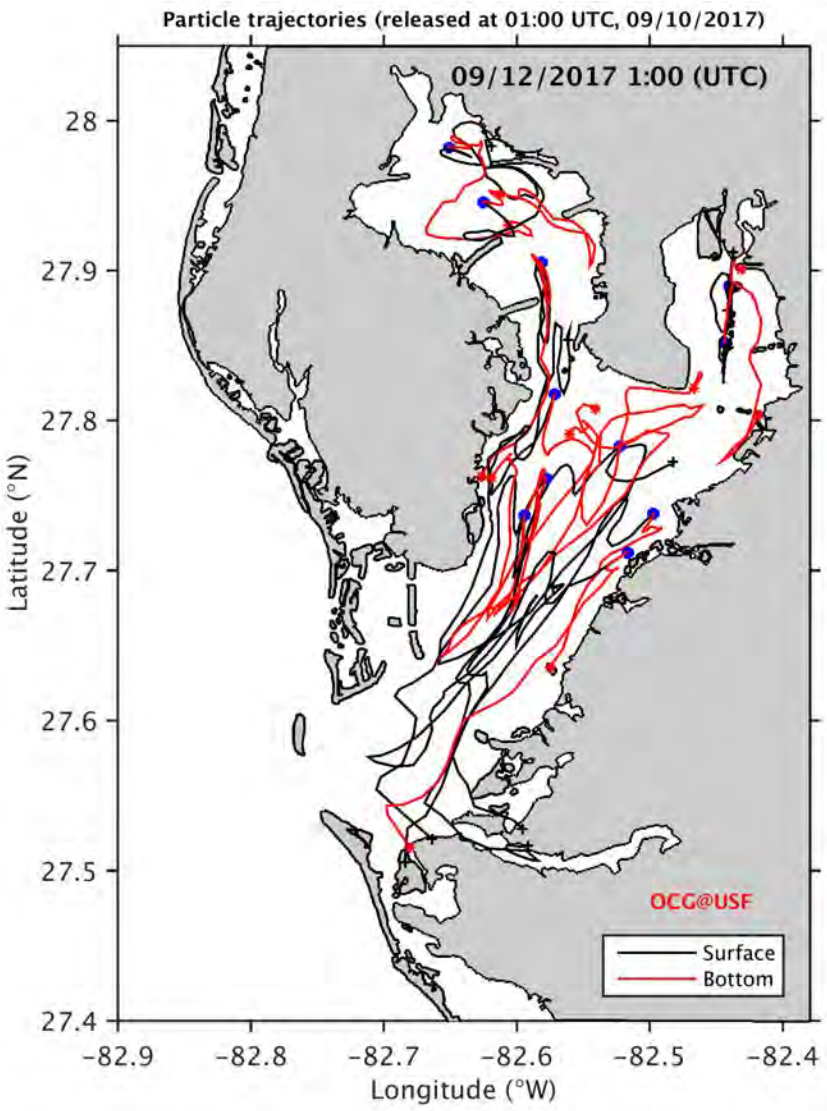


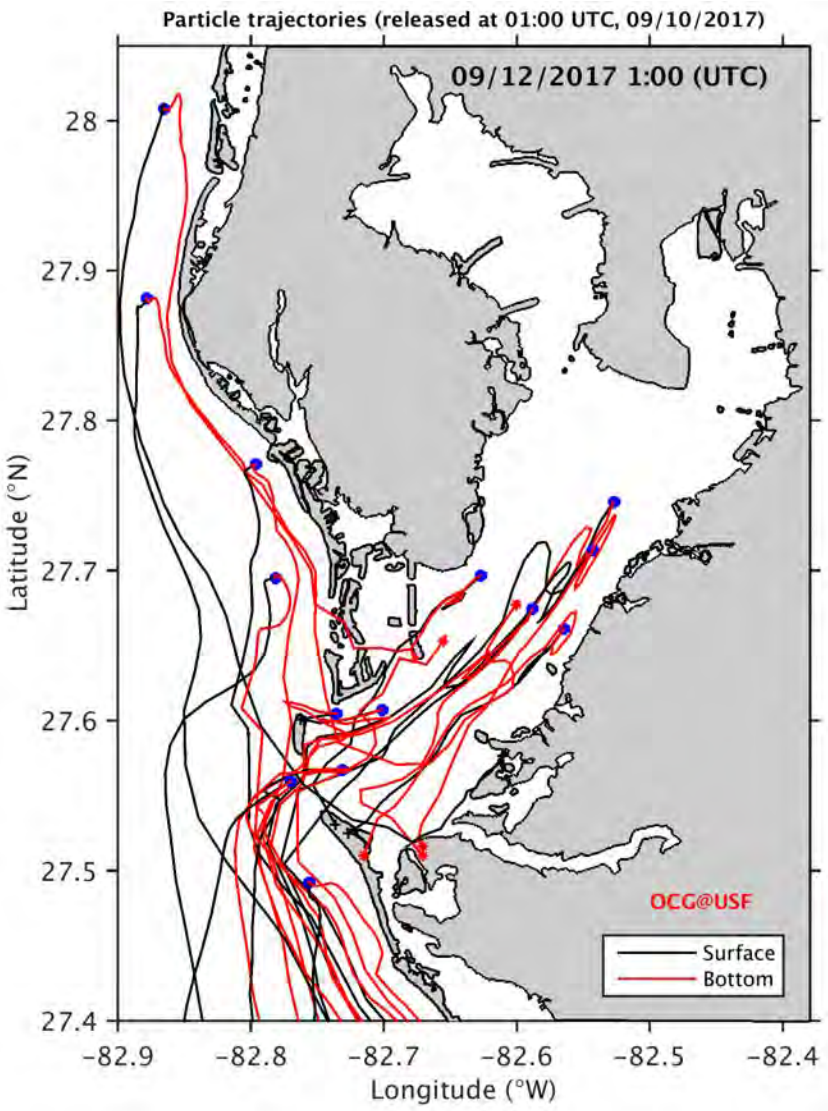
Lagrangian Drifter Trajectories During Hurricane Irma Simulated by TBCOM

From where did water leave the bay?

Answer: From the lower portion of Tampa Bay.



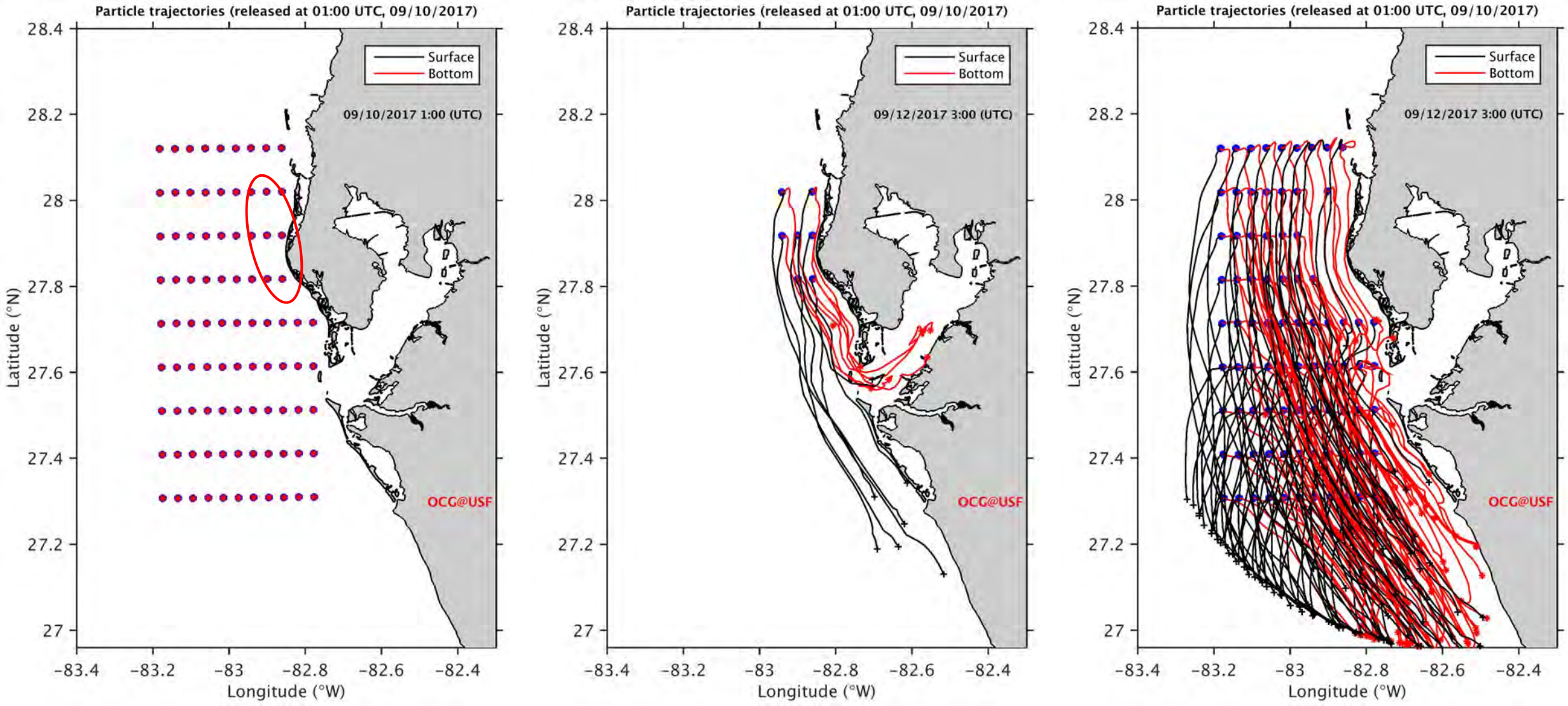




Lagrangian Drifter Trajectories During Hurricane Irma Simulated by TBCOM

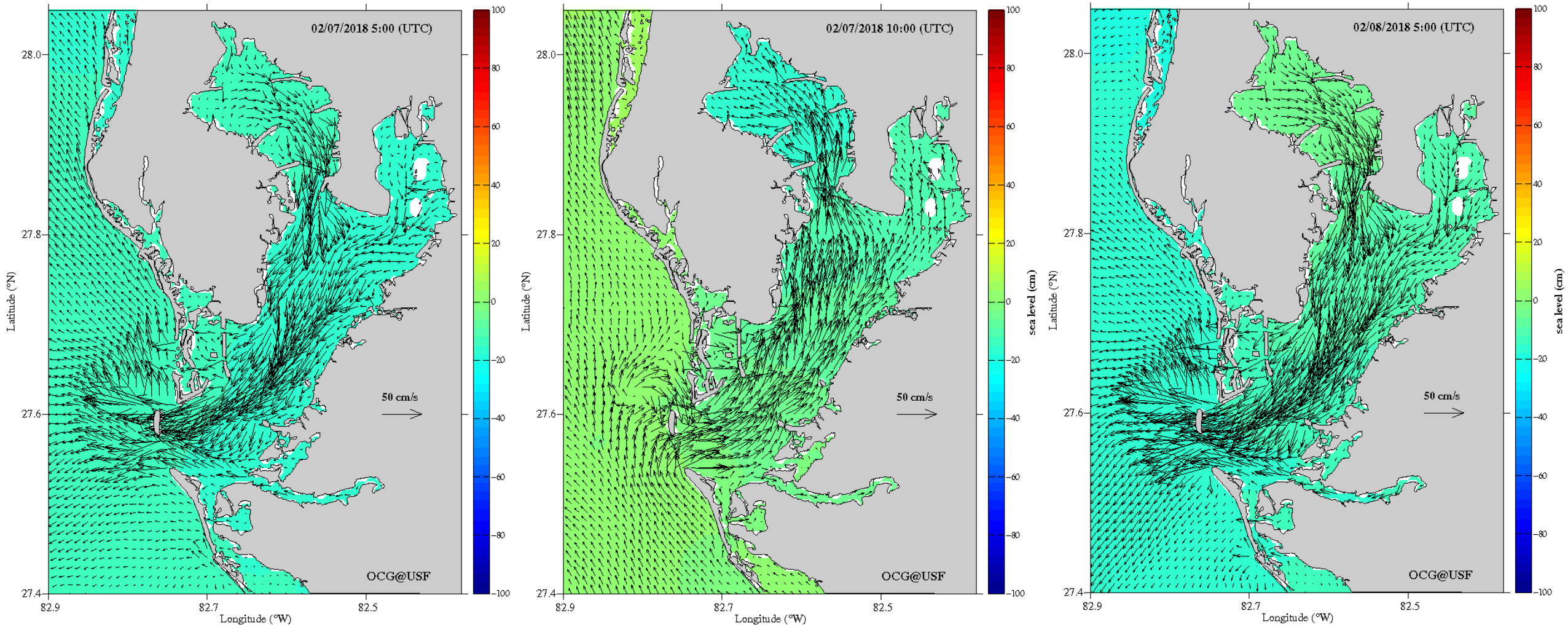
From where did the new water enter the bay?

Answer: From nearshore of Indian Rocks Be. and Clearwater and primarily from the bottom versus the surface.

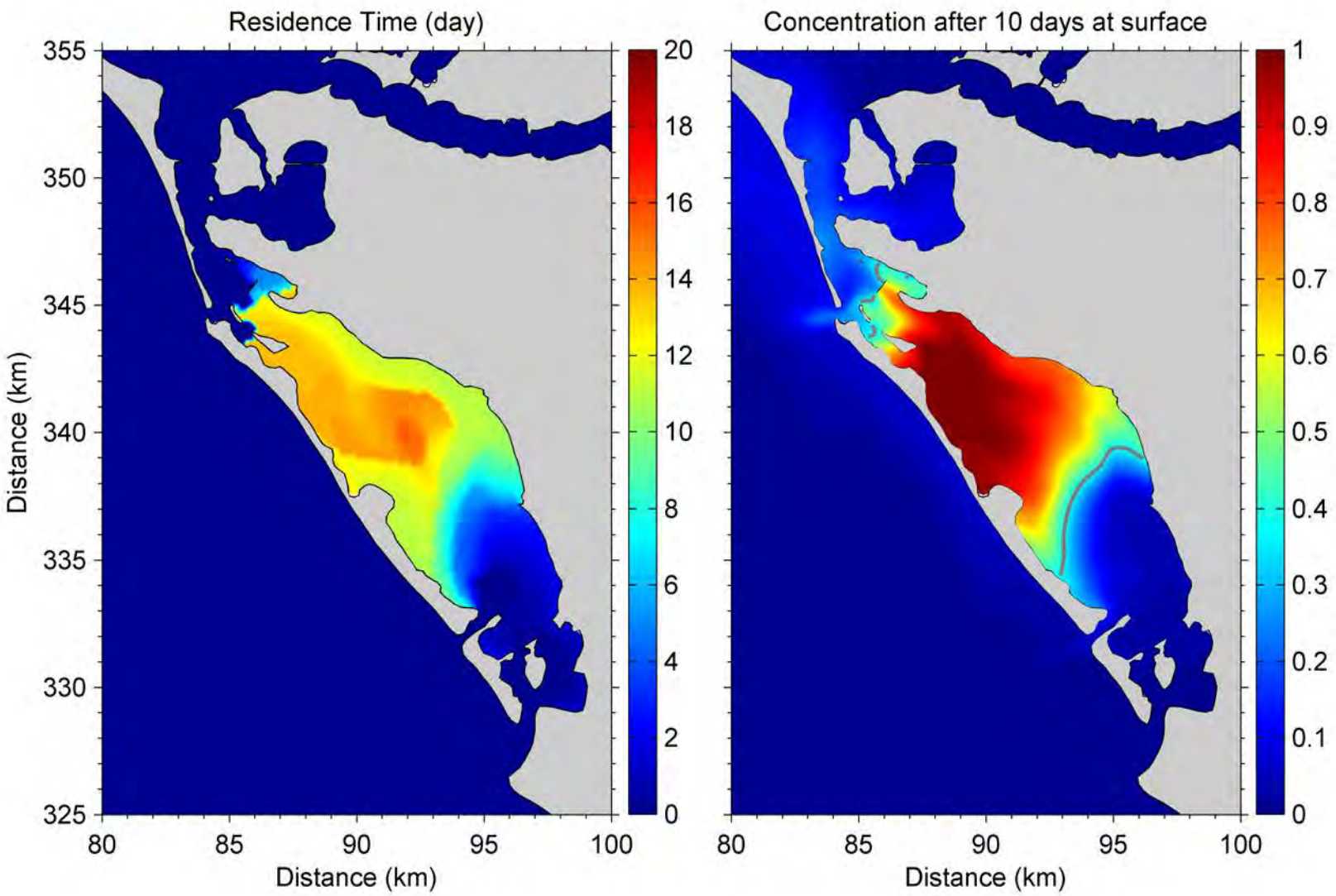


TBCOM is presently run daily as an automated nowcast/forecast model. Shown below are surface currents and sea level for 0500 UT and 1000 UT on 2/7/18 and 0500 UT on 2/8/18 providing examples of maximum ebb, flood and ebb again.

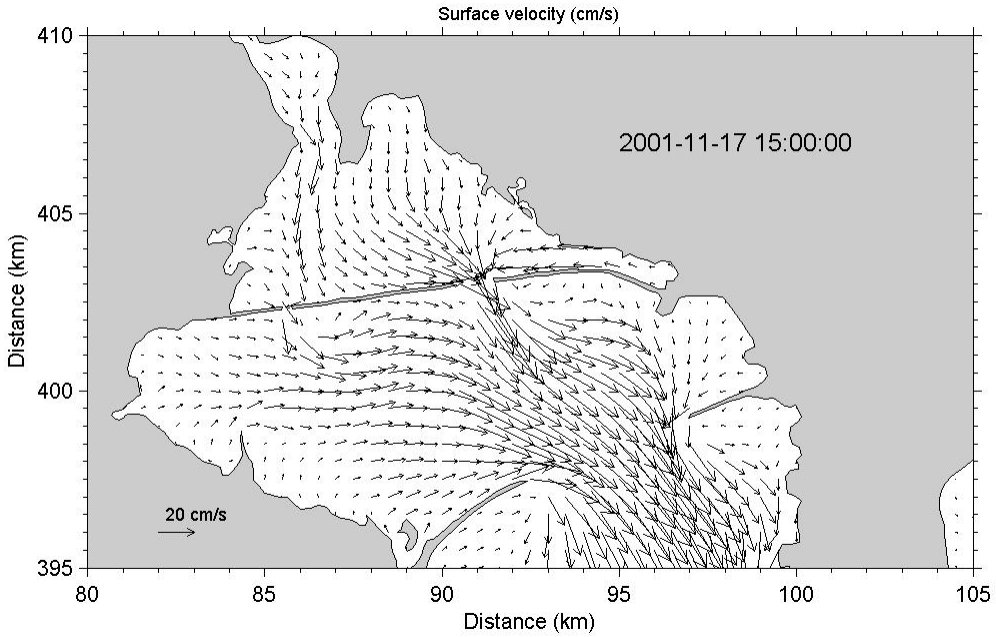
Note: 1) the complexity of the currents requiring high resolution and 2) how the TB currents broadly impact the adjacent coastline to the north and south.

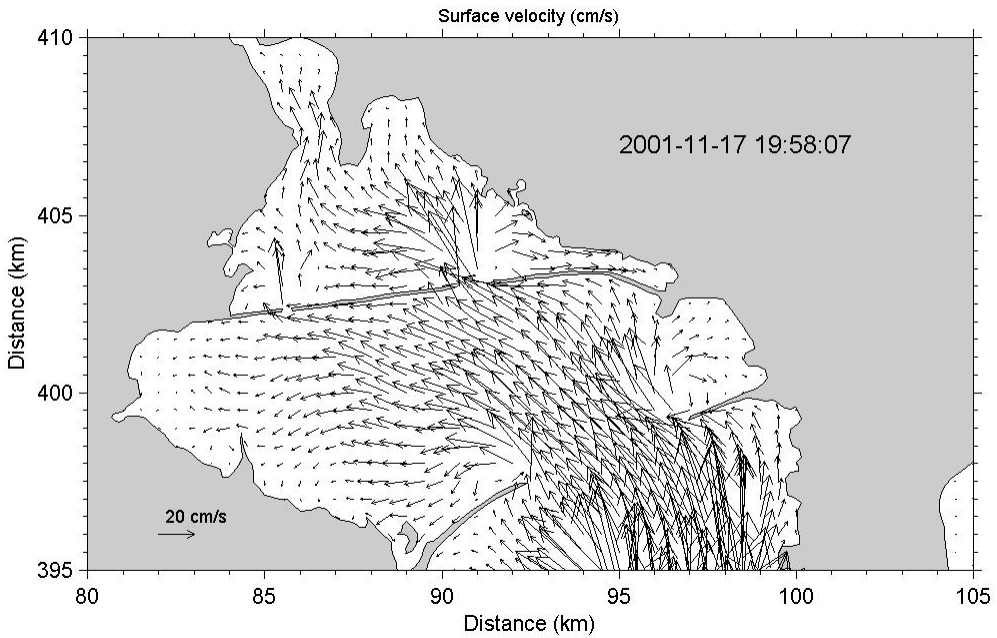


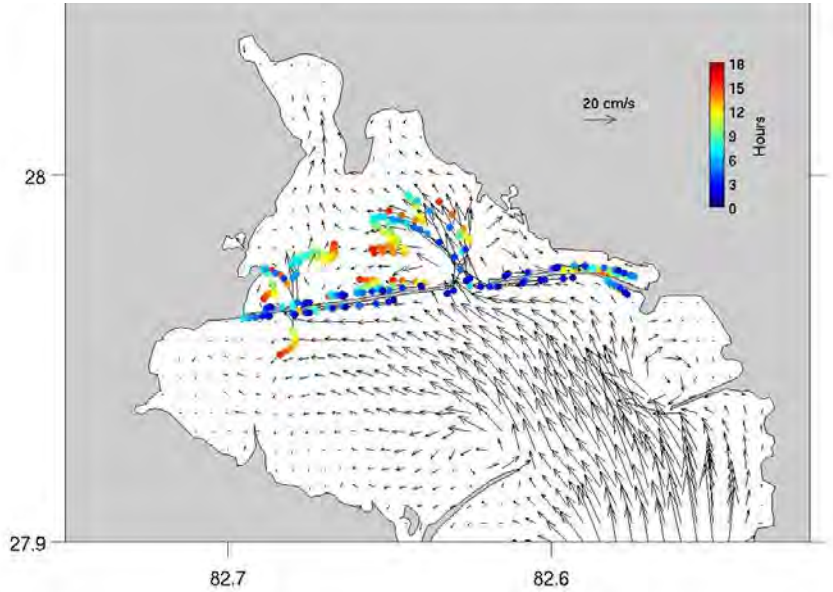
Potential TBCOM Applications: 1) Flushing of restricted water bodies, 2) Search and rescue, 3) Forensic studies, 4) Fish larvae studies, 5) Harmful spill tracking, 6) Impact by water diversion.

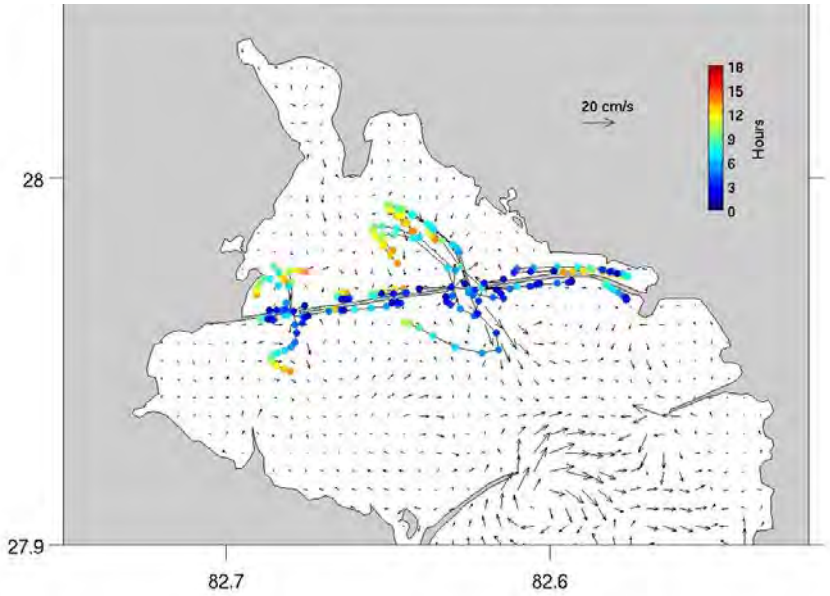


Potential TBCOM Applications: 1) Flushing of restricted water bodies, 2) Search and rescue, 3) Forensic studies, 4) Fish larvae studies, 5) Harmful spill tracking, 6) Impact by water diversion.



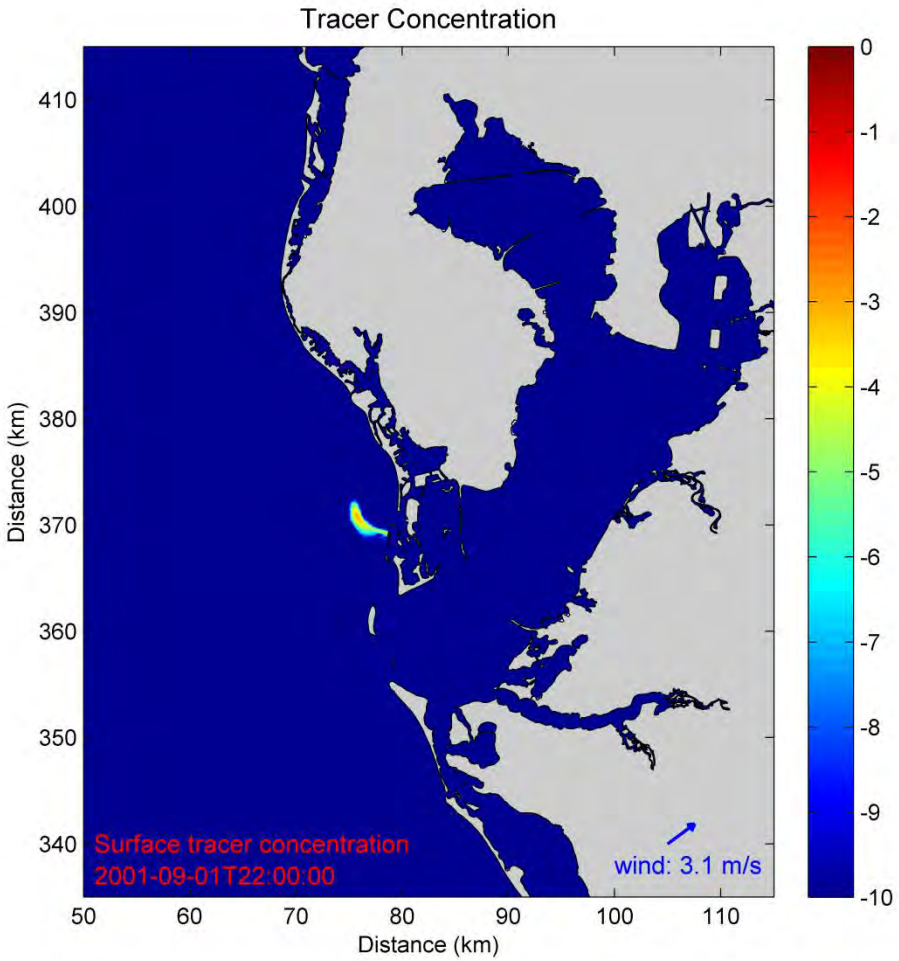




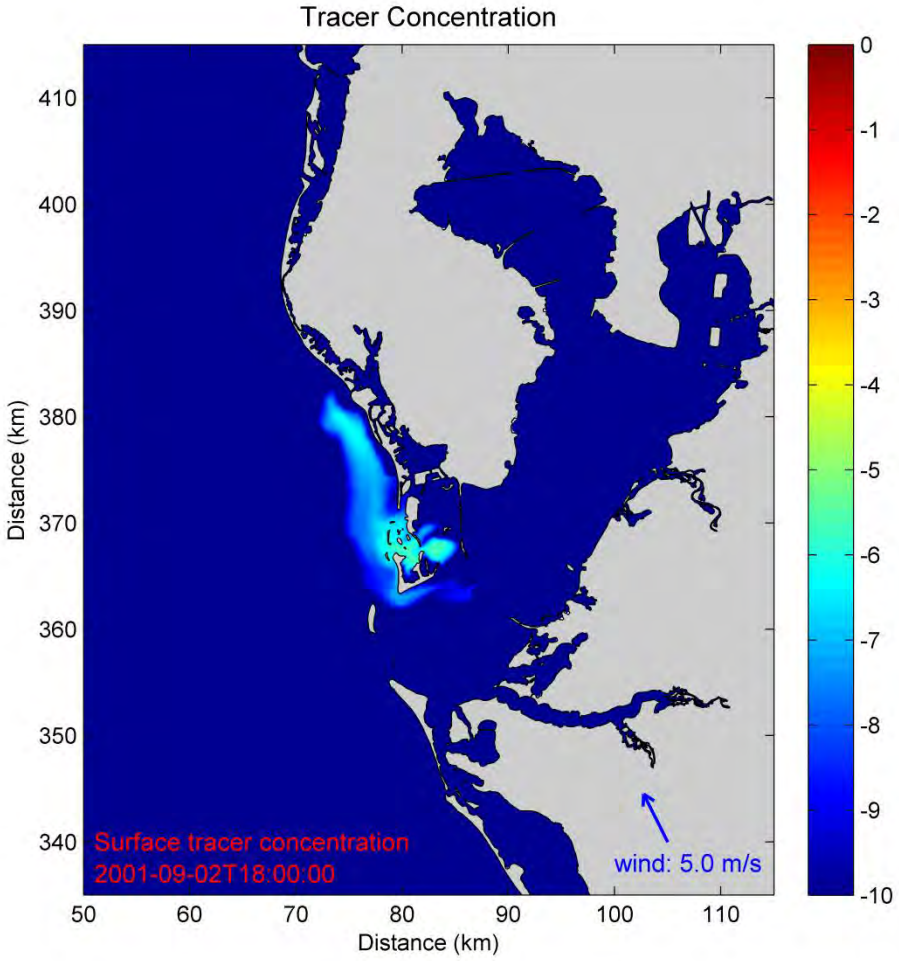


Potential TBCOM Applications: 1) Flushing of restricted water bodies, 2) Search and rescue, 3) Forensic studies, 4) Fish larvae studies, 5) Harmful spill tracking, 6) Impact by water diversion.

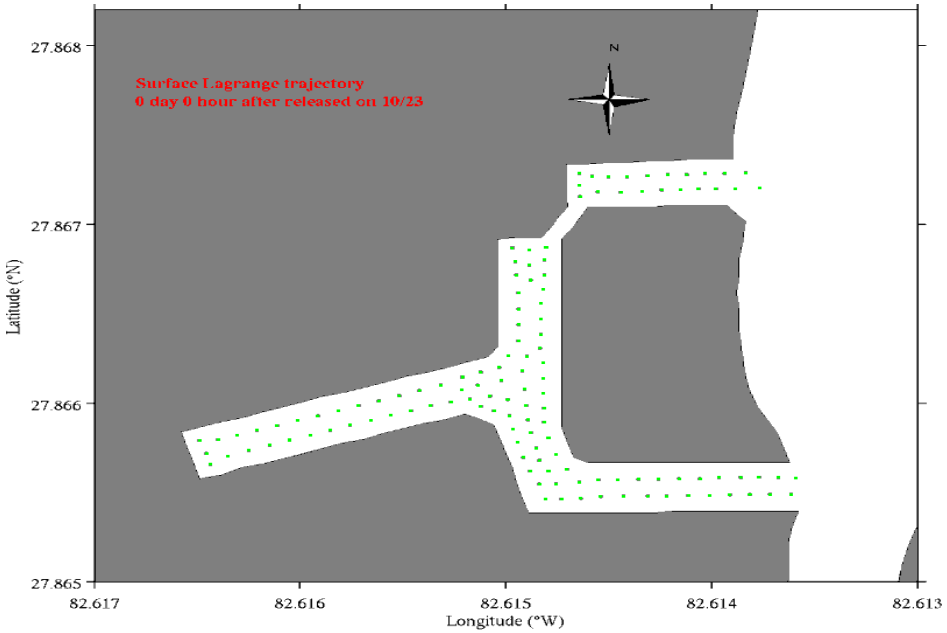
Concentration 6 hours after spawning



Concentration 24 hours after spawning

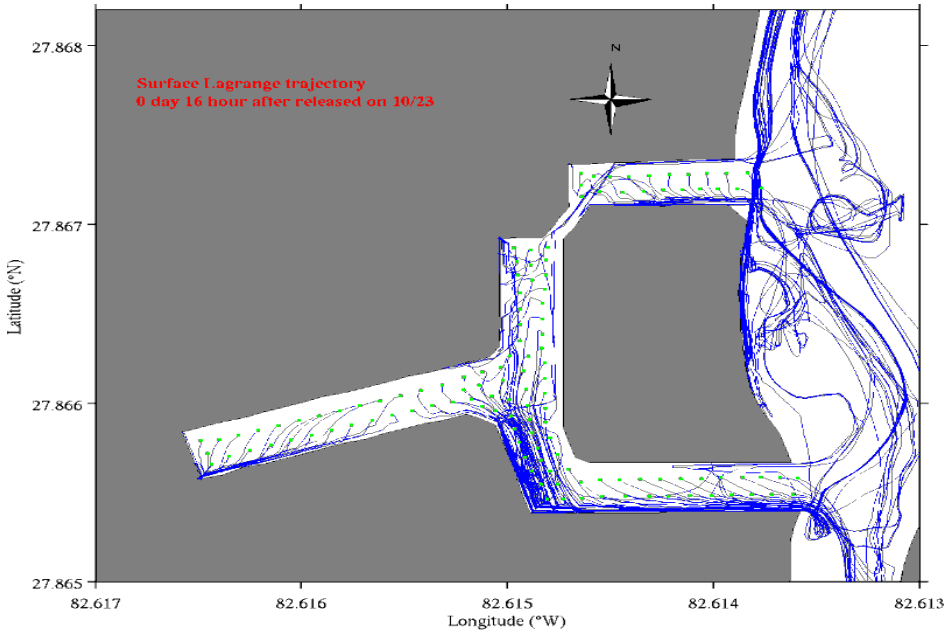


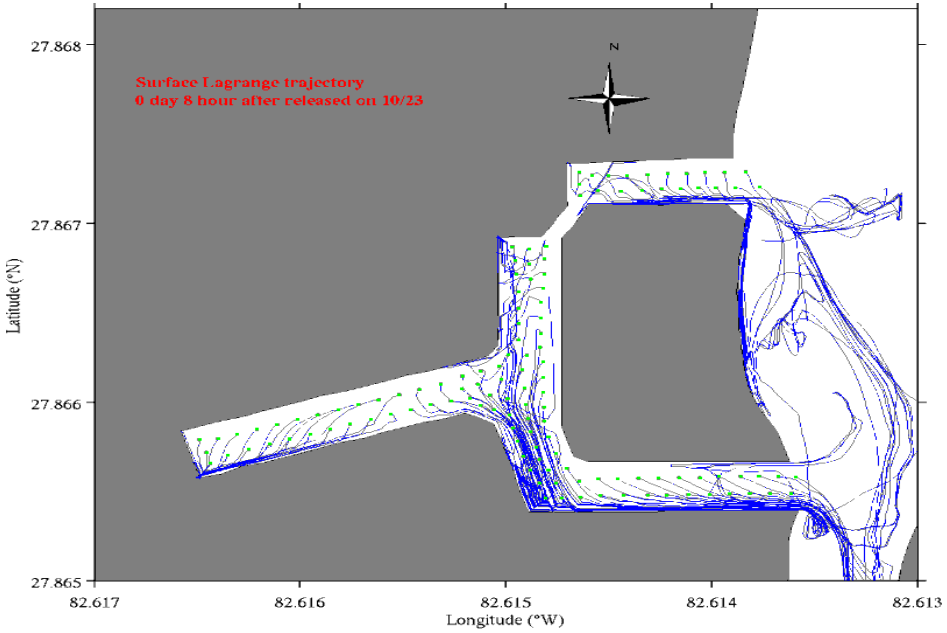
Potential TBCOM Applications: 1) Flushing of restricted water bodies, 2) Search and rescue, 3) Forensic studies, 4) Fish larvae studies, 5) Harmful spill tracking, 6) Engineering studies.



Initial locations at 0000, 10/23/01

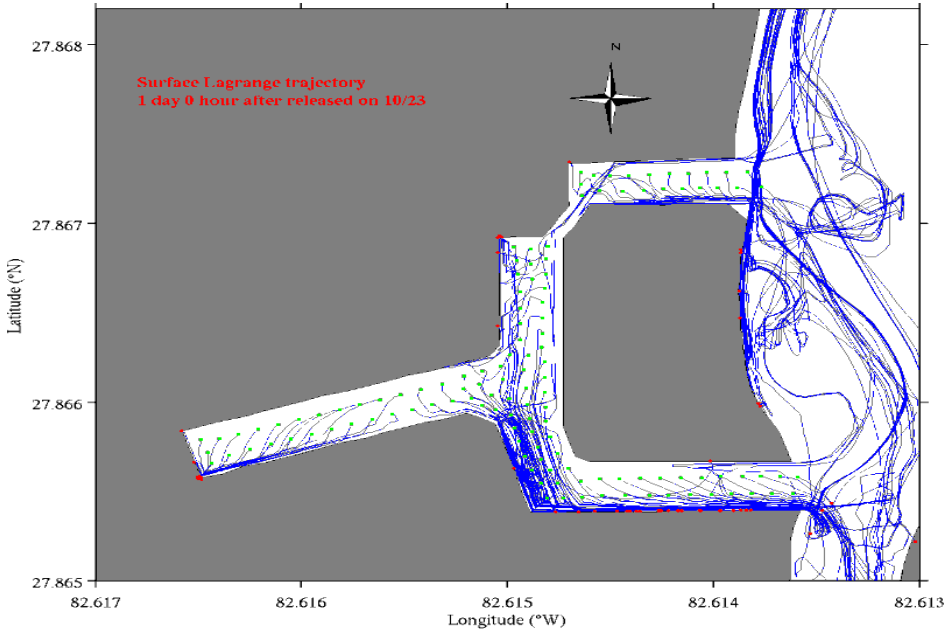
Locations at 0000, 10/23/01





Locations at 0800,10/23/01

Locations at 2400, 10/23/01



Conclusions

- **WFCOM performed well for the WFS response to IRMA, including Florida Bay and the Charlotte Harbor/Sanibel estuary.**
- **The higher resolution TBCOM performed well for Tampa Bay during Irma, especially when the winds were corrected to match observations.**
- **Observations are critical to model performance and veracity testing, providing strong justification for IOOS and the direct coordination between observations and models.**
- **Both WFCOM and TBCOM are run daily as automated nowcast/forecast models.**
- **Given TBCOM and its WFCOM counterpart we have the capability to downscale from the deep ocean, across the shelf and into the estuaries, providing opportunity for multidisciplinary studies.**
- **We are looking for partners for addressing matters of ecology, fisheries, sediment transport, emergency management, engineering and forensic concern. All of these applications begin with the circulation.**
- **We are also looking for ways to better provide information of use by the general public.**

Additional Acknowledgments

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Jeff Donovan for all aspects of data and computer systems management

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