Relationships between Turbidity and Bottom Shear Stresses in Terrebonne Bay, Louisiana

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Introduction

Accurate estimation and prediction of turbidity in coastal and estuarine areas play a significant role in coastal environmental management and coastal ecosystem restoration.

Turbidity Increases in coastal areas can seriously harm aquatic lives, habitat, and as a results, the whole ecosystem.

To develop a better understanding of turbidity changes in Terrebonne Bay, LA, effects of following parameters on turbidity have been studied:

- $Turbidity = f(d, H_s, T_p, u_*, u_{wb})$
- $Turbidity = f(u_{10}, Wind\ Fetch, Wind\ Direction)$
- $Turbidity = f(Sea, Swell)$
- $Turbidity = f(\tau_{Total}, \tau_{Wave}, \tau_{Current})$

Practical relationships were developed to estimate turbidity in the bay from measured aforementioned parameters in the area.

Study Area & Method

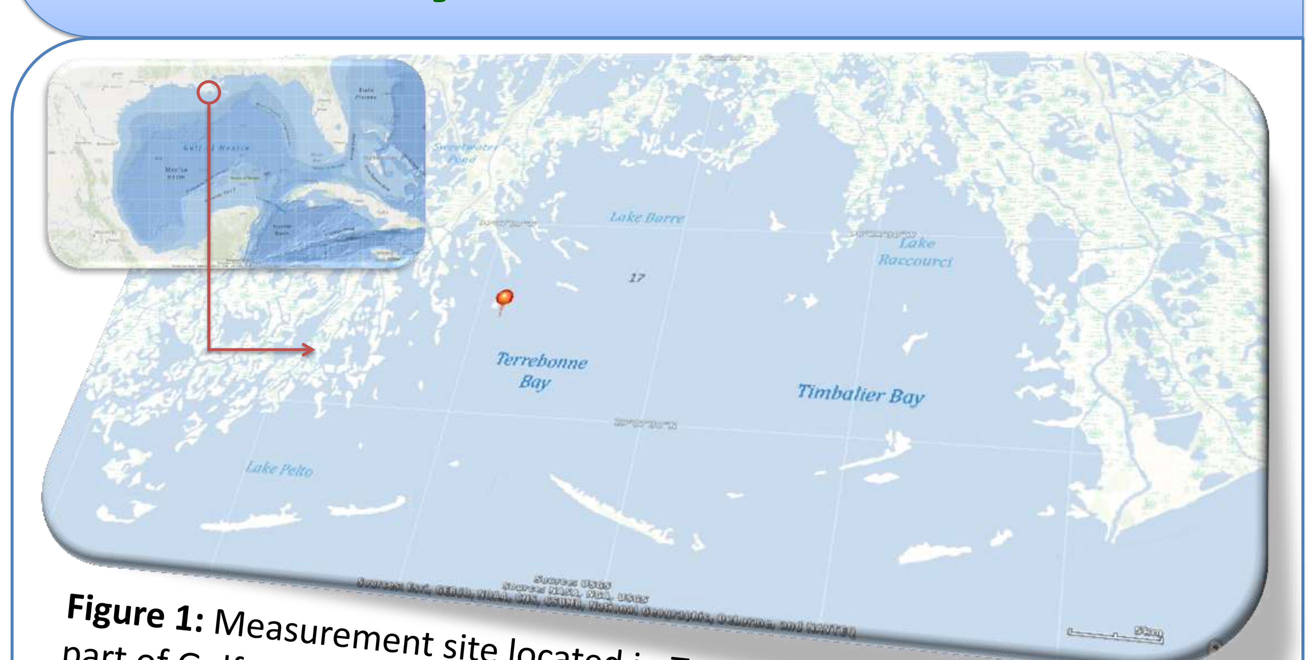

Figure 1: Measurement site located in Terrebonne Bay, north part of Gulf of Mexico, on the coast of Louisiana, USA *

Figure 2: Sontek Triton ADV installed on tripod stand.

Location:
- 29°11'13.20"N , 90°36'33.59"W

Time:
- 8/24/2010 - 12/31/2010

Instrument:
- Sontek Triton ADV

Measured Parameters:
- Velocity at 1.09 m from sea bed
- Pressure at 0.80 m from sea bed

Sampling:
- Frequency: 2 Hz
- Burst duration: 1024s/1800s

* Map extracted from ArcGIS Explorer

Results

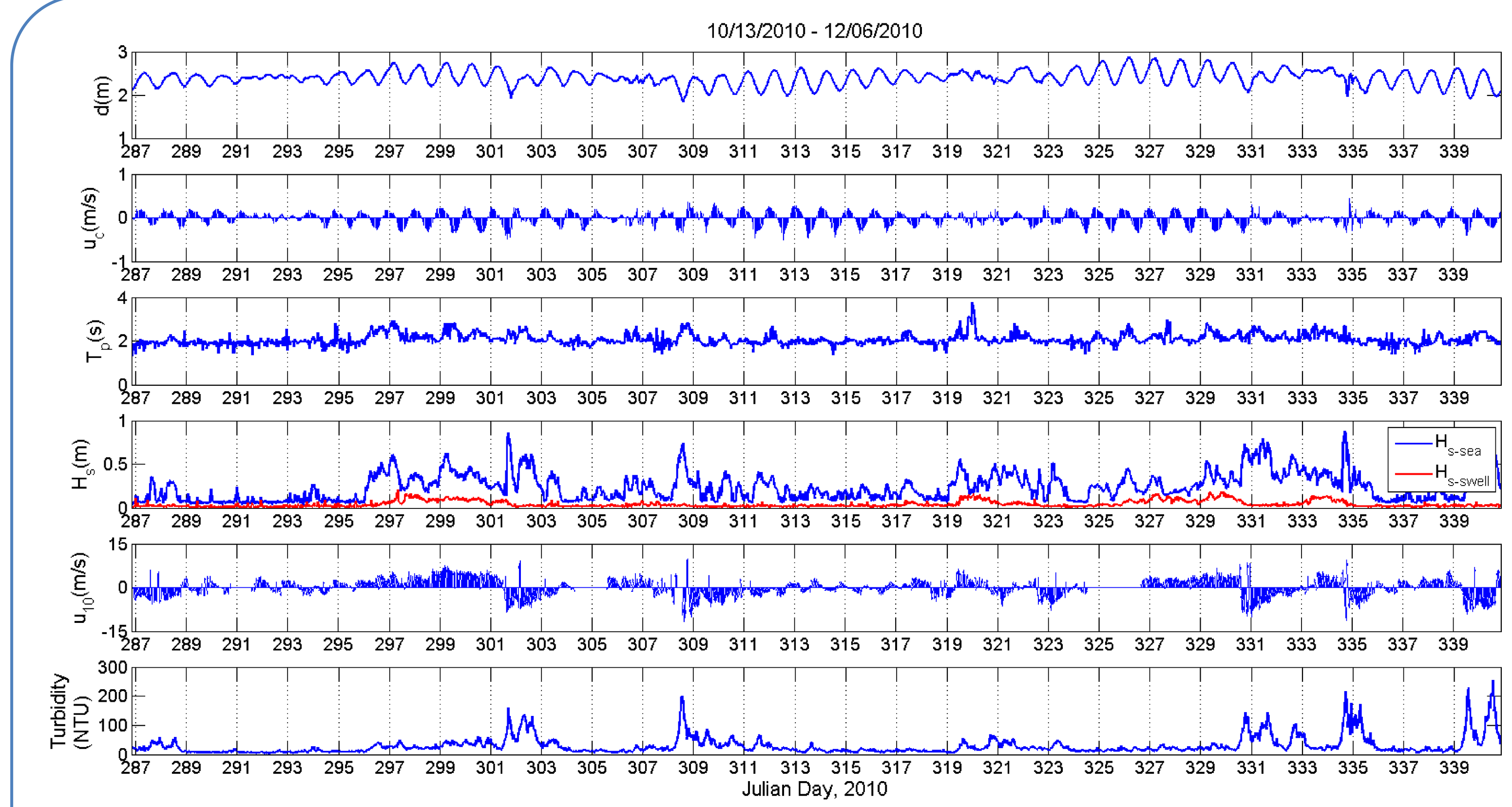

Figure 3: Time series of measurement from 13/10/2010 to 6/12/2010. From top to bottom: 1) Water depth d, 2) Current velocity/direction u_c at 1.09 m from bed, 3) Wave peak period T_p, 4) Significant wave height H_s for sea and swell, 5) Wind velocity/direction u_{10}, and 6) Water turbidity. Wind and current vectors show both magnitude and direction.

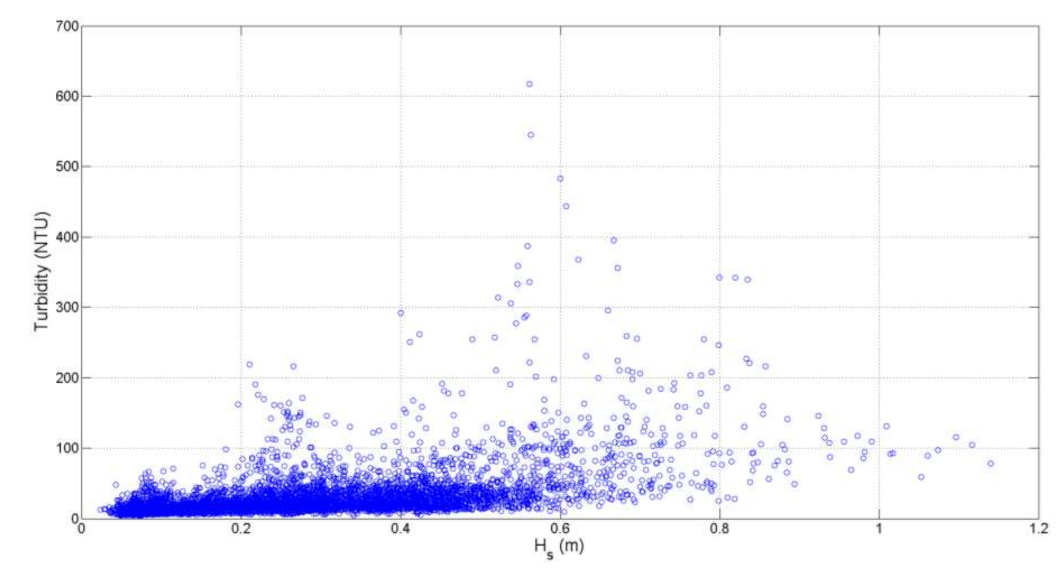

Figure 4: Turbidity versus significant wave height H_s in Terrebonne bay for measurement from 24/8/2010 to 31/12/2010. Peak turbidity occurs at significant wave height about $H_s \sim 0.6\ m$, and by decreasing or increasing a wave height from that value, turbidity in bay decreases.

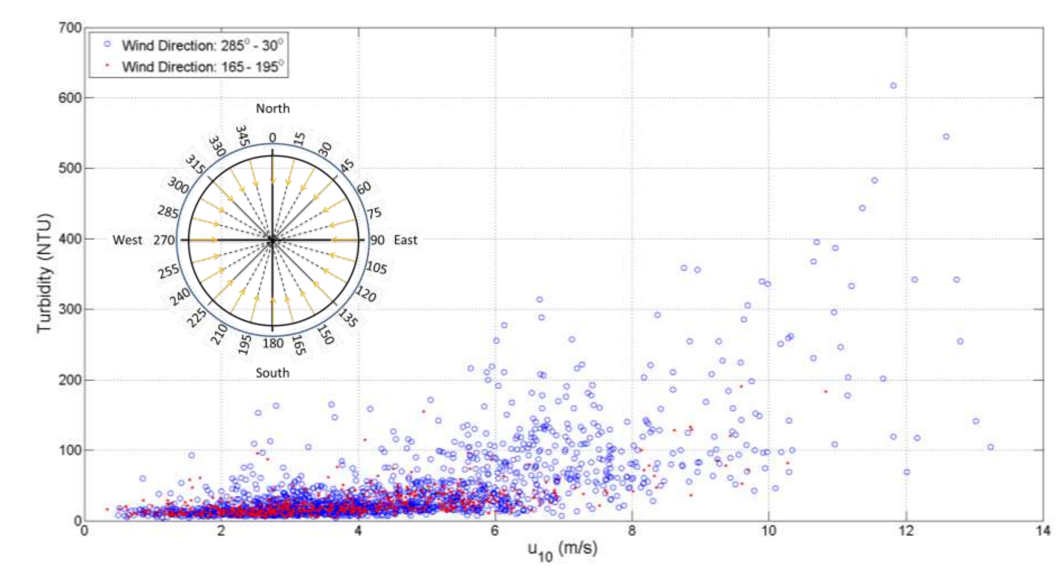

Figure 5: Turbidity versus wind velocity u_{10}, separated based on wind direction, in Terrebonne bay for measurement from 24/8/2010 to 31/12/2010. Northerly wind ($wind\ direction \sim 285^{\circ} - 30^{\circ}$) associated with large turbidity values, while southerly wind ($wind\ direction \sim 165^{\circ} - 195^{\circ}$) only causes mild changes in turbidity.

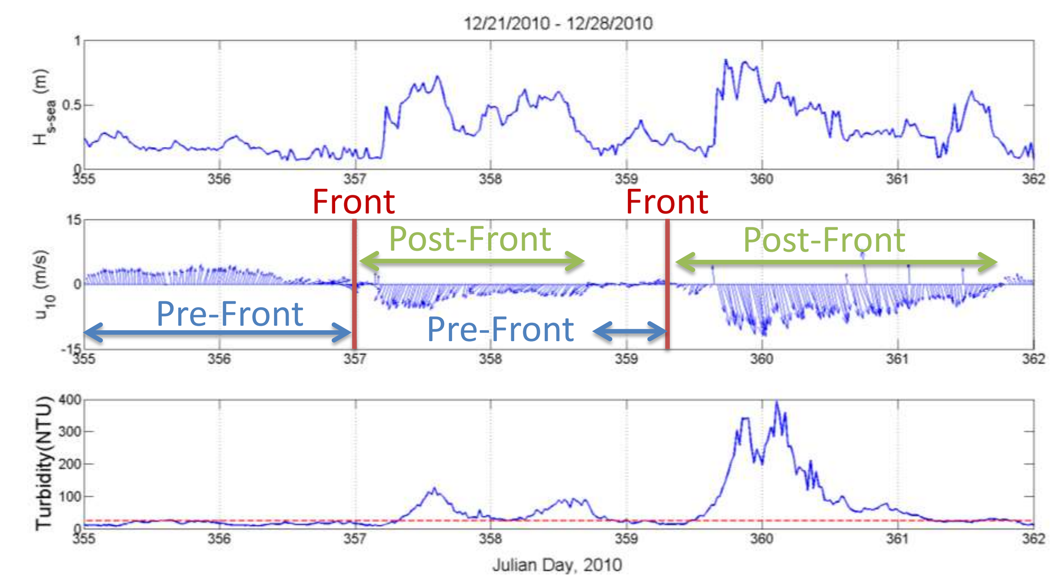

Figure 6: Two cold front passage in Terrebonne bay from 21/12/2010 to 28/12/2010. Fronts (red vertical lines) and their pre and post front phases are illustrated. From top to bottom: 1) Sea significant wave height H_{s-sea}, 2) Wind velocity/direction u_{10}, and 3) Turbidity. Increases in wave height and turbidity can be seen in post-front phase. Horizontal dashed line in plot (3) represents average turbidity for wind direction between 135° and 225° equal to 23.7 NTU.

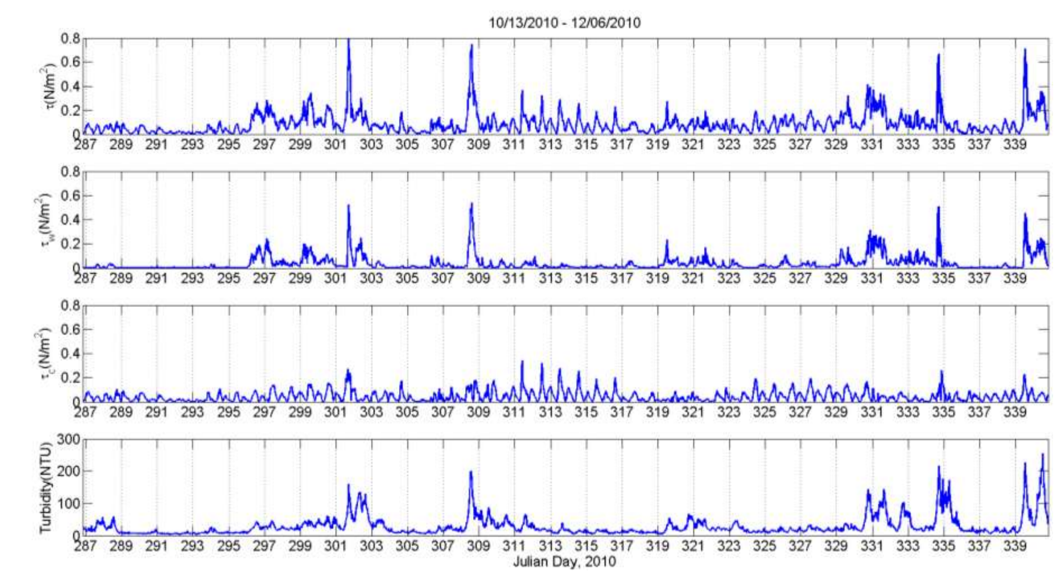

Figure 7: Bottom shear stress time series in Terrebonne bay from 13/10/2010 to 6/12/2010. From top to bottom, 1) Total bottom shear stress τ under interaction of wave and current, 2) Bottom shear stress due to wave activity τ_w, 3) Bottom shear stress due to near bottom current τ_c, and 4) turbidity.

Bottom shear stress is always less than critical shear stress ($\tau_e \sim 1.59\ N/m^2$), which means turbidity does not have local sources and materials are carried to the bay from surrounding wetlands and adjacent shallow area.

Turbidity Estimation

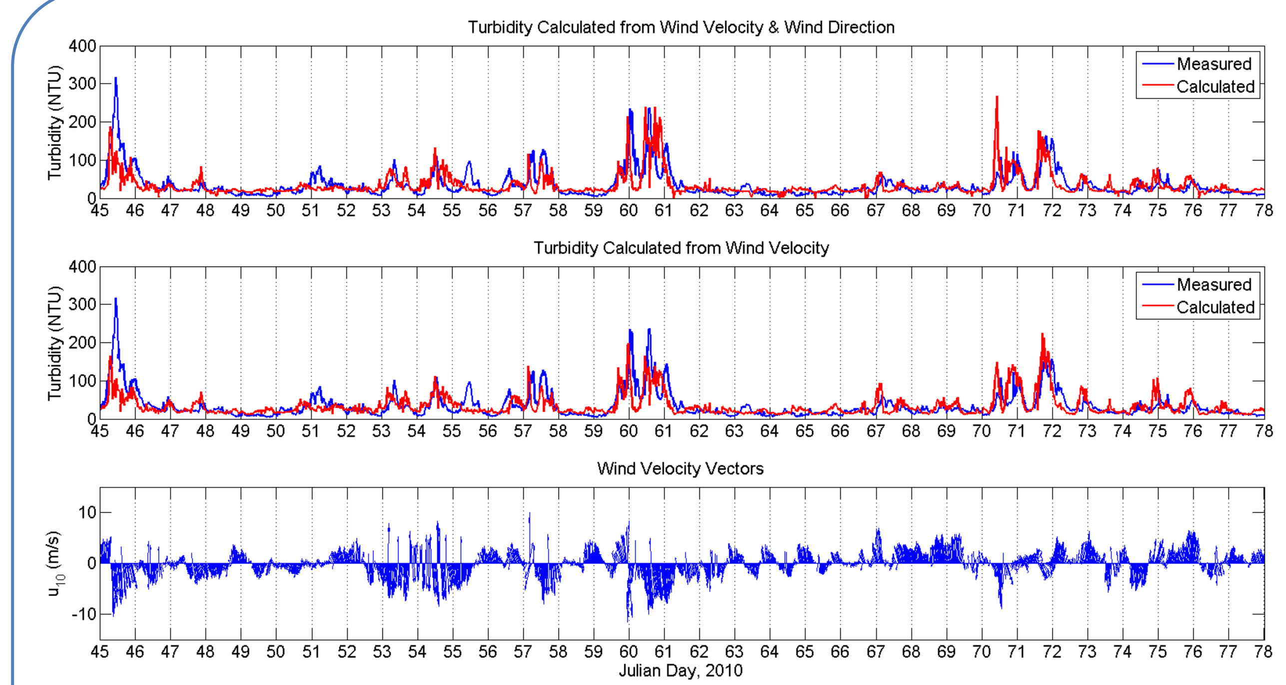

Figure 8: Comparison of predicted turbidity with measured turbidity in Terrebonne bay from 14/2/2010 to 19/3/2010. From top to bottom, 1) predicted turbidity using wind velocity u_{10} and wind direction, 2) predicted turbidity using only wind velocity, and 3) wind velocity vectors. Except for first peak, both method predict all turbidity peaks with good accuracy.

Conclusion

- Wave and tidal activities, bottom current, and swell are not solely responsible for turbidity changes in Terrebonne Bay.
- Bottom shear stress does not reach to critical threshold at measurement location, which means turbidity does not have local sources.
- High turbidity values are correlated with the strong northerly winds.
- Main source of turbidity in the bay is suspended materials form surrounding wetlands and adjacent shallow area, that are carried to the bay during the cold front passage.
- Turbidity in the bay can be estimated by using wind velocity and its direction with good accuracy.

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