Impact of wave forcing on sediment resuspension and transport in the Mississippi Sound and Bight

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Introduction

- Sediment resuspension increases light attenuation, which thereby impacts ecosystem dynamics on the shelf by limiting primary production and other planktonic interactions.
- The sediment transport is also important for the filter feeders such as oysters in the estuarine waters of Mississippi Sound because high sediment loads can cause reduced fitness leading to decreasing populations.
- Therefore, it is important to understand the impact of forcing agents causing sediment resuspension in the water column.

Objectives

- This study aims to investigate the impact of wave forcing on sediment transport, with a primary focus on suspended sediment distribution and sediment re-suspension events.
- Field data collected during multiple cruises of CONCORDE (Consortium for oil spill exposure pathways in Coastal River Dominated Ecosystems) indicate sediment resuspension events on Western Mississippi Bight in spring.
- Model simulations are initialized for those time periods to analyze wave-driven sediment transport and also to explore the balance between wave- and current-driven sediment transport in Mississippi Sound and Bight.

Study Area

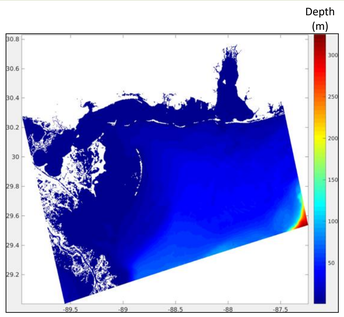

Figure 1. CONCORDE model domain with bathymetry

The study area covers the shelf of western Mississippi Bight under the influence of freshwater plumes from Mississippi River and Mobile Bay.

CONCORDE had multiple cruises in the study area in Fall 2015, Winter, Spring and Summer 2016 and studied N-W corridors. In this study, the focus is on the Spring cruise time period (March-April 2016) and the Western Corridor of CONCORDE along with mixing array stations near Mississippi River and Mobile Bay. (See Figure 6.)

Methods – CONCORDE Synthesis Model

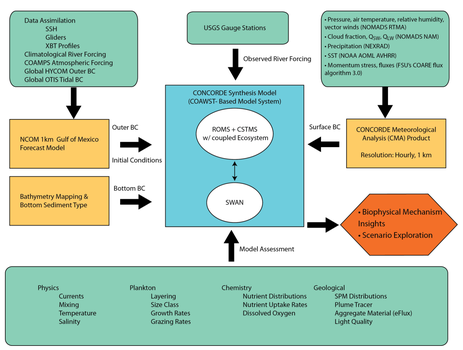

Figure 2. Conceptual diagram of CONCORDE synthesis model

The CONCORDE Synthesis model within the Coupled Ocean Atmosphere Wave Sediment Transport (COAWST) model (Warner et al., 2010) framework is used to study the dynamics in the Mississippi Bight as part of the CONCORDE.

CONCORDE Model Details:

- 400 m horizontal resolution (580 x 370 horizontal grid points)
- 24 vertical layers
- Community Sediment Transport Modeling System (CSTMS) is used in this study.
- External wave forcing is generated using WAVEWATCH III products.

Impact of waves on resuspension events

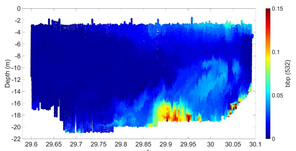

Figure 3. Particle backscattering along CONCORDE Western Corridor on April 1, 2016.

The Scanfish (with AC-9) towed by R/V Pelican along CONCORDE Western Corridor on 04/01/2016 observed a resuspension event at a depth of approximately 18-20 m.

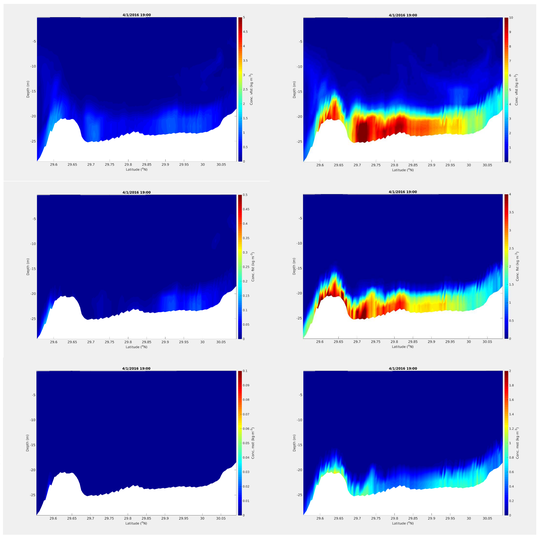

Figure 4. Model results for very fine silt, fine silt and medium silt concentrations along CONCORDE Western Corridor on April 1, 2016 at 14:00.

- The resuspension event was also observed in the model for multiple sediment classes.
- Model results at 1400 hrs. shows increased sediment concentration near bed along the western corridor.
- The resuspended sediment concentration is enhanced and the sediment concentrations are approximately an order of magnitude larger once wave forcing is added into the model simulation.
- The location of resuspension shifts towards south with the addition of wave forcing.
- Once wave forcing is added; the resuspension is the strongest at the northern part of the sill for very fine silt while it is stronger on the sill for fine silt and the resuspension is stronger towards the northern section of the corridor for medium silt.
- There is no medium silt resuspension without wave forcing and the resuspension induced by waves is in line with measurements.

Impact of waves on bottom sediment distribution

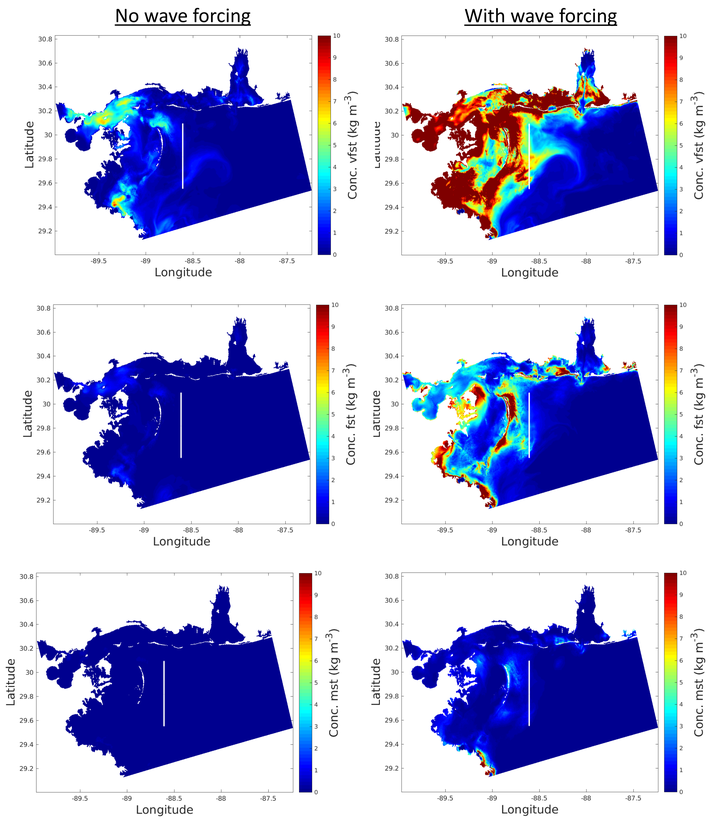

Figure 5. Model results of bottom concentrations for very fine silt, fine silt and medium silt on April 1, 2016 at 14:00.

- Wave forcing causes increased very fine silt resuspension in shallow estuarine waters (of Mississippi Sound, Chandeleur Sound, Mobile Bay and Breton Sound) and shallower (d<20m) parts of the shelf.
- Bottom concentrations of fine and medium silt are larger with wave forcing.
- A feature of suspended very fine silt crossing the western corridor is observed in the case without wave forcing indicating that it is advection due to currents.
- The same feature is enhanced in the case with wave forcing for very fine silt.
- The increased near-bottom sediment concentrations captured along the Western Corridor are a result of combined wave-current action with sediment resuspended due to waves being advected into the deeper parts of the shelf by the currents while crossing the corridor.

Impact of waves at stations near freshwater plumes

Total sediment concentrations over the water column during the CONCORDE Spring cruise time period (29 March – 8 April 2016) for very fine, fine and medium silt classes is calculated at 6 stations south of Mobile Bay Main Pass and at 5 stations Northeast of Mississippi River Bird-Foot Delta has been analyzed.

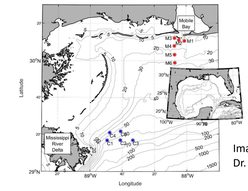

Image courtesy of Dr. Sabrina Parra

Figure 6. Fall (blue) and Spring (red) mixing array stations

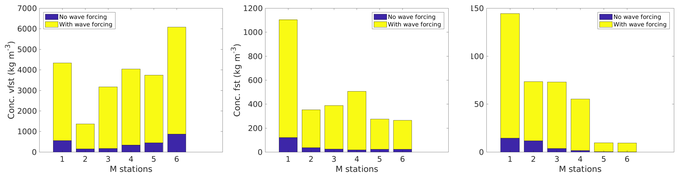

Figure 7. Total sediment concentration in the water column near Mobile Bay Main Pass from March 29 to April 8 2016 from model simulations with (yellow) and without (blue) wave forcing.

The modeled sediment concentrations for silt classes (very fine, fine, medium) in the water column is integrated over depth and time to find the total concentration during the Spring cruise. Both medium and fine silt concentrations are the highest at station M1 which is the station closest to Mobile Bay shipping channel. The very fine silt concentration is the highest at the deepest station, M6. The total medium silt concentrations are highest at M1, M2 and M3 stations closer to Main Pass while the impact of waves is stronger (up-to 42 times) at deeper stations (M4,M5,M6). The total fine silt concentrations are consistently an order of magnitude (8 to 26 times) higher at all stations in the case with wave forcing. The total very fine silt concentrations are 6 to 17 times stronger with waves.

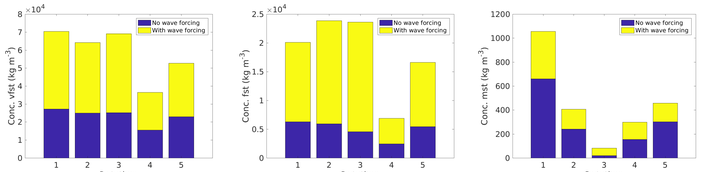

Figure 8. Total sediment concentration in the water column near MS River Bird-Foot Delta from March 29 to April 8 2016 from model simulations with (yellow) and without (blue) wave forcing.

The impact of waves is not as pronounced in the deeper Fall mixing array stations near MS River Bird-foot delta. The wave induced total sediment concentrations are close to the model results with no wave forcing and may even be smaller at some stations for medium silt.

Conclusions and remarks

This preliminary study aimed to understand the impact of waves on spatial and temporal distribution of sediment in the study area. The findings show:

The high near-bottom concentrations observed in the field may be captured by the model. The waves have a strong affect on sediment resuspension in shallow areas of western Mississippi Bight and estuarine waters causing higher near-bottom suspended sediment concentrations. The combined wave current action causes sediment transport into deeper parts of the shelf

Waves dominate the suspended sediment concentrations at shallowe rwaters near Mobile Bay main pass while the impact of waves is weaker in deeper stations near Mississippi river.

This preliminary study will be expanded to analyze the impact on all sediment classes including sand and clay. The seasonality of the impact of waves will be studied by adding an analysis of sediment concentrations during Fall, Winter and Summer CONCORDE cruise times. Wave-current interactions will be studied using coupled SWAN-ROMS simulations within the COAWST modeling system.

References:

Greer A.T. et al. (2018) "Functioning of Coastal River-Dominated Ecosystems and Implications for Oil Spill Response: From Observations To Mechanisms And Models", *Oceanography*, Vol.31, No.3.

Warner, J.C. et al. (2010). Development of a Coupled Ocean-Atmosphere-Wave-Sediment Transport (COAWST) modeling system. Ocean Modelling 35(3):230–244

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