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The effects of tropical cyclones on marine sediment organic matter in the Mississippi River plume

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Introduction

- Hurricane-induced extreme precipitation can lead to flooding & high discharge to coastal zones[2].
- These extreme events can mobilize large quantities of organic carbon (OC) and potentially alter biogeochemical processes in the receiving coastal marine sediments[1].
- Refining our understanding of how storms impact carbon cycling will help better model carbon sequestration in dynamic coastal environments.
- Our main question:

How do extreme weather events alter the fate of sedimentary carbon, and what does this reveal about the vulnerability of coastal systems to intensifying climate disturbances?

Methods

- Sediment cores were collected at sentinel sites (August 2021, December 2021, March 2022, June 2022, August 2022, September 2024, January 2025).
- Storm of interest: Hurricane Francine, 12 September 2024.
- Loss on ignition (LOI) analysis was performed using standard protocols.
- LOI% was calculated using dry weight (DW) as: $\%LOI = ((DW_{60}-DW_{550})/DW_{60})*100$
- Two-tailed T-tests were performed to compare values across sampling periods.

Figure 1. *Map of the southeastern Louisiana coastal zone showing sampling locations*. The cruise track departing from Louisiana Universities Marine Consortium (LUMCON) and the locations of Stations 1 and 3, where our sediment cores were collected, are shown. Red X's mark the two stations, with their corresponding latitude and longitude listed below.

Station 1: 28.94° N, -89.76° E
Station 3: 28.86° N, -90.49° E

LOI Results

Station 1

- Pre- and post-storm LOI (0-15 cm) showed significant difference ($p = 0.0014$).
- Surface (0-2 cm) LOI increased 83% 2 days after Francine compared to prior years;
- Surface (0-2 cm) LOI decreased by 16% from 2 to 9 days post-storm, but there was no significant difference from 0 to 15 cm ($P = 0.36$).
- Surface (0-2 cm) LOI did not change ~4 months post-storm, nor was there any significant difference from 0 to 15 cm ($P = 0.18$).

Station 3

- Surface LOI (0-2 cm) increased 106% 4 days after Francine compared to prior years; pre- and post-storm LOI (0-15 cm) showed significant differences ($P = 0.017$).
- LOI (0-2 cm) increased by 4% ~4 months post-storm with no significant differences from 0 to 15 cm.

Acknowledgements and References

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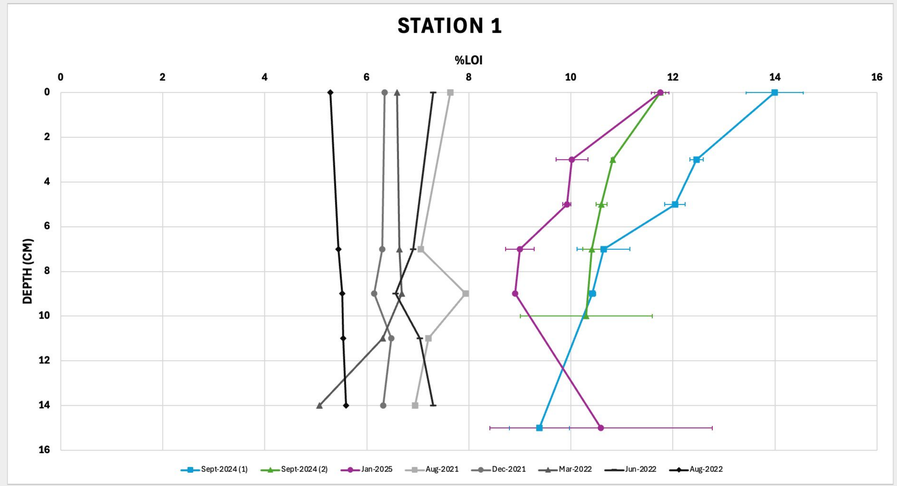


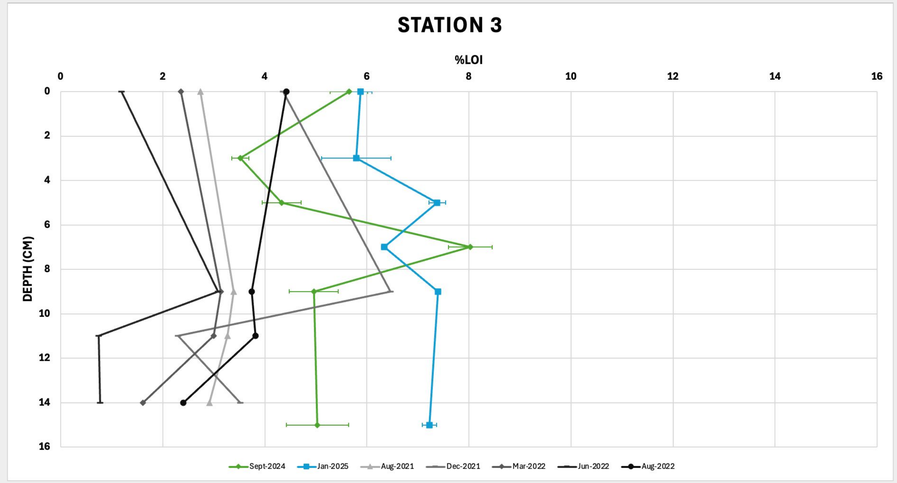
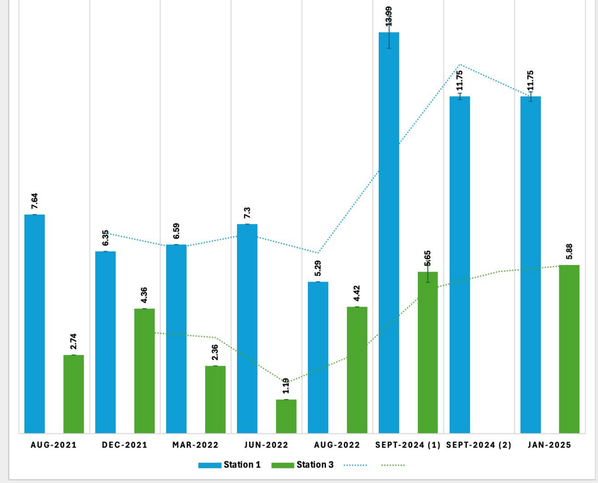


Figure 2 (top left, bottom left). *Loss on ignition (LOI) profiles by depth at Stations 1 and 3.* Plots show LOI (%) in the upper 15 cm of sediment for various months in 2021, 2022, 2024, & 2025. The upper panel displays Station 1 profiles; the bottom panel displays Station 3 profiles. Distributions illustrate differences in columnal sediment organic matter content (0-15 cm) between the two sites. Data points for 2024 and 2025 are averages of triplicate samples from each depth; the error bars are the standard deviation.

Figure 3 (below). *Histogram comparing loss-on-ignition (LOI) values from the upper 2 cm of sediment cores collected at Station 1 (blue) and Station 3 (green).* Distributions illustrate differences in surface sediment organic-matter content between the two sites. Data points for 2024 and 2025 are averages of triplicate samples from each depth; the error bars are the standard deviations for each depth.



Implications

Potential explanations for the observed LOI patterns:

- **Delivery of terrestrially derived organic matter (OM) by Hurricane Francine.**
- **Transport of clay-rich materials into the MR plume which possess the ability to both structurally bind water and/or sequester OM.**
- **A combination of both processes.**

Future Work

- Next step: stable carbon isotope ($\delta^{13}C$) analysis
- $\delta^{13}C$ comparisons will allow us to:
  - Differentiate terrestrial vs. marine organic matter sources.
  - Assess whether post-Francine LOI increases reflects OM values or inflation from clay-bound water and/or mineral-organic complexation.
  - Estimate the amount of carbon deposited during the storm.
- Combined with POC data, $\delta^{13}C$ will clarify local short-term (days) and long-term (interannual) sedimentary carbon dynamics following an extreme weather event.