

Multivariate analysis of the influences of oceanic and meteorological processes on suspended particulate matter distributions in Mississippi coastal water

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Abstract

The Mississippi Sound is influenced by a high volume of sediment discharge from the Biloxi River, Mobile Bay via Pas aux Herons, Pascagoula River, Pearl River, Wolf River, and Lake Pontchartrain through the Rigolets. The river discharge, variable wind speed, wind direction and tides have a significant impact on the turbidity and transport of sediments in the Sound. Level 1 Moderate Resolution Imaging Spectroradiometer (MODIS) data is processed to extract the remote sensing reflectance at the wavelength of 645 nm and binned into an 8-day composite at a resolution of 500 m. The study uses a regional ocean color algorithm to compute suspended particulate matter (SPM) concentration based on these 8-day composite images. Multivariate analysis is applied between the SPM and time series of tides, wind, turbidity and river discharge measured at federal and academic institutions' stations and moorings. The multivariate analysis also includes in situ measurements of suspended sediment concentration and advective exchanges through the Mississippi Sound's tidal inlets between the coastal shelf and the nearshore estuarine waters. Mechanisms underlying the observed spatiotemporal distribution of SPM, including material exchange between the Sound and adjacent shelf waters, will be explored. The results of this study will contribute to current understanding of exchange mechanisms and pathways with the Mississippi Bight via the Mississippi Sound's tidal inlets.

Data Sources

Data was collected during summer and fall 2015 at Ship Island, Mississippi and Dauphin Island, Alabama. Particle size distribution was measured with a LISST particle size analyzer. This sensor measures light diffracted by particles to determine the size distribution of particles in the water column.

Suspended particulate matter concentration was measured at some stations by filtering water samples unto pre-combusted and preweighed 1.5 μm Whatman GF/F filters. Filters were dried at 105 °C to a constant mass and reweighed to estimate the concentration of SPM. Filters were flushed with nanopure water after filtering to prevent the accumulation of salt in the filter's pore spaces (Zhao, 2011).

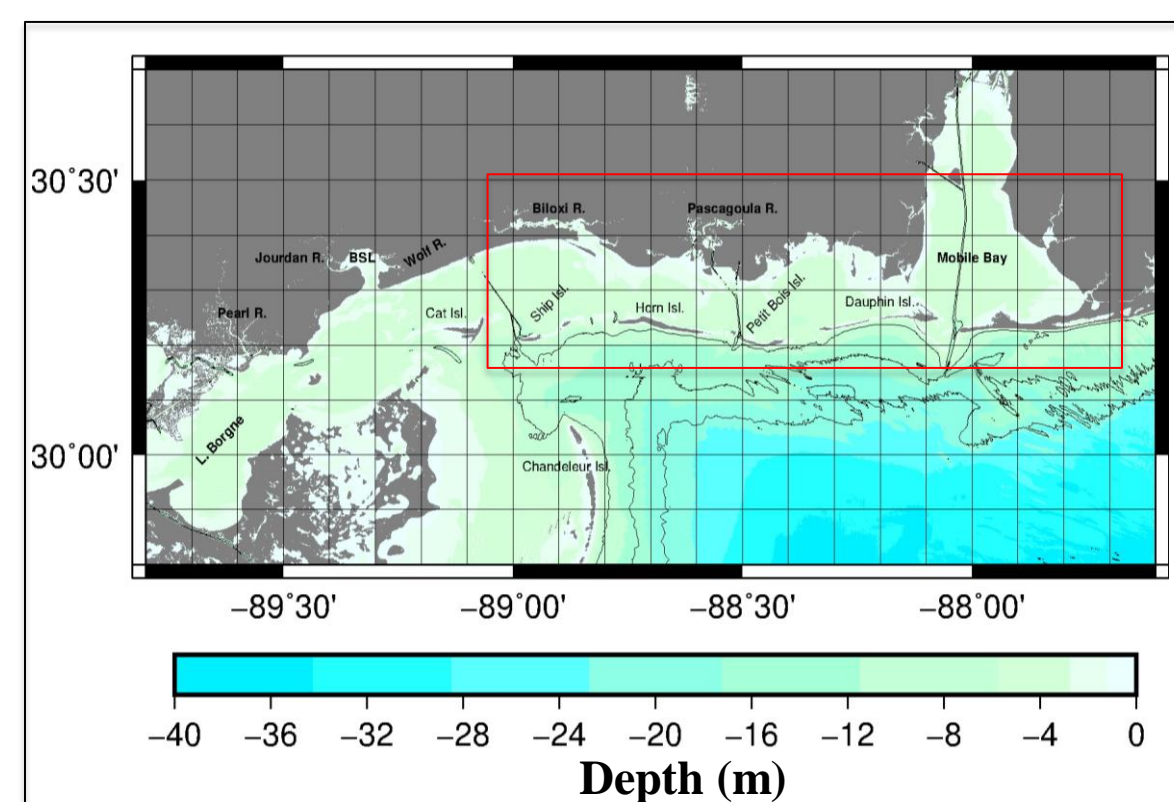


Figure 1. a) Location map of study region highlighted in red.

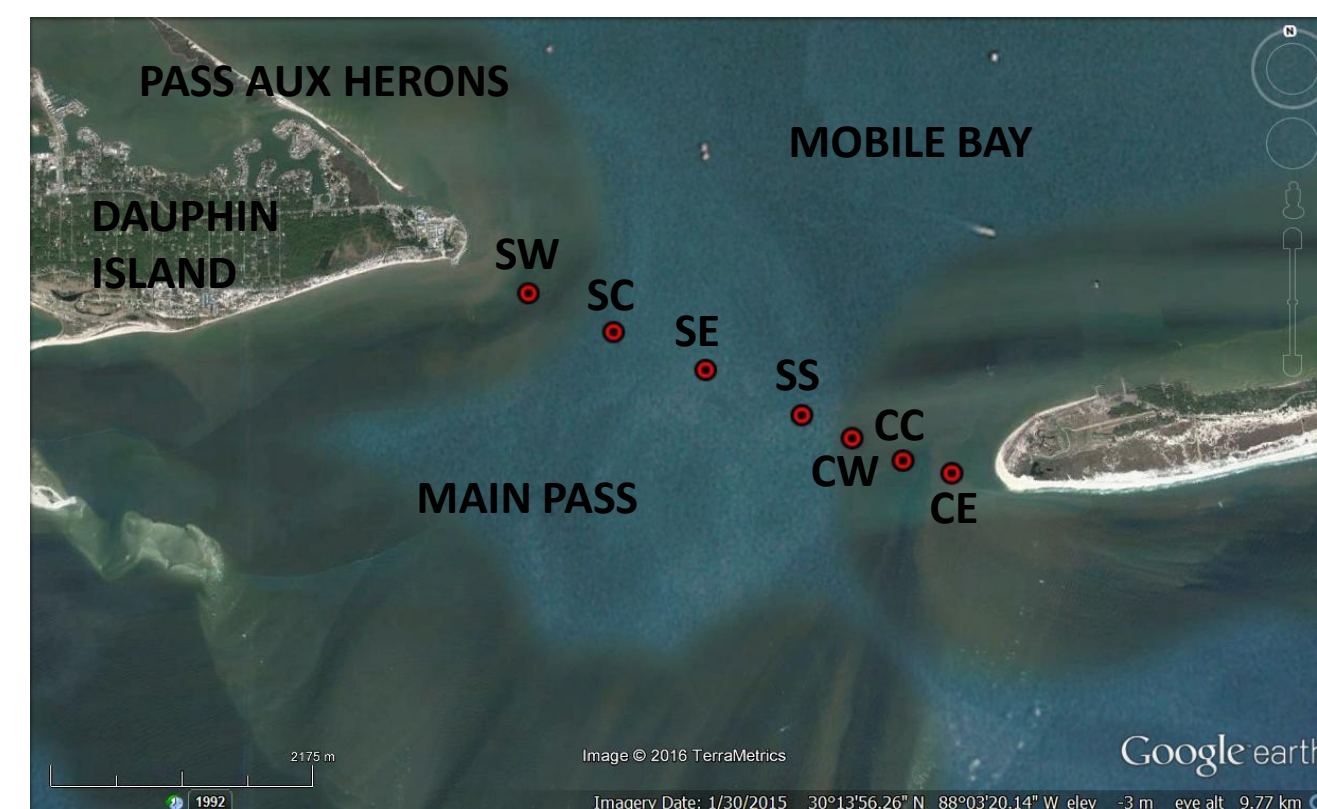


Figure 1. b) Dauphin Island stations sampled on 10/29/2015. 'S' denotes shoal stations (depth < 5.0 m) and 'C' indicates stations located in Mobile Shipping Channel. Water samples were collected at SC and CC. This sampling effort was preceded by a weather system associated with Hurricane Patricia that made landfall in Mexico on 10/20/2015. Mobile received record precipitation (6.87 in) between 10/25 - 10/27/2015 (https://www.google.com/earth/).

Effects of Hurricane Patricia Weather System

- The weather system associated with Hurricane Patricia resulted in the third largest water level event in the last six years at Dauphin Island (figure 2a).
- The variation in the drifter tracks (Figure 2c) indicates the fresher estuarine water preferentially advects out Mobile Bay via the ship channel pathway, while a return flow appears to develop on the western shoal of Main Pass (surface salinity > 30 psu).

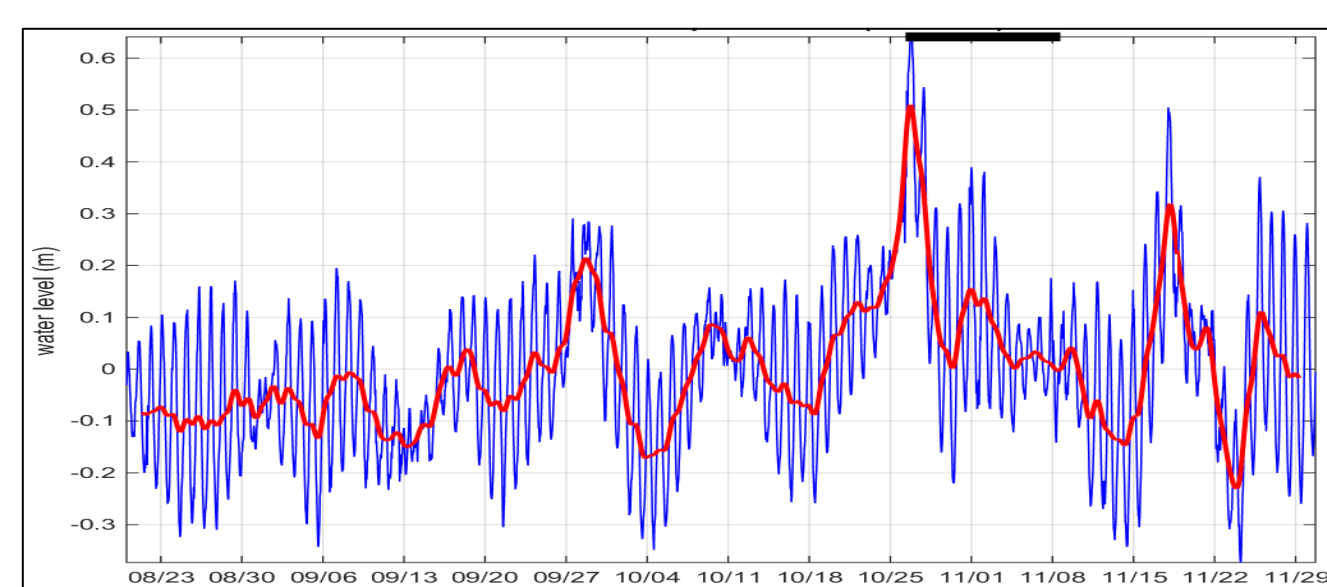


Figure 2. a) Water level at Dauphin Island for the period August to November 2015.

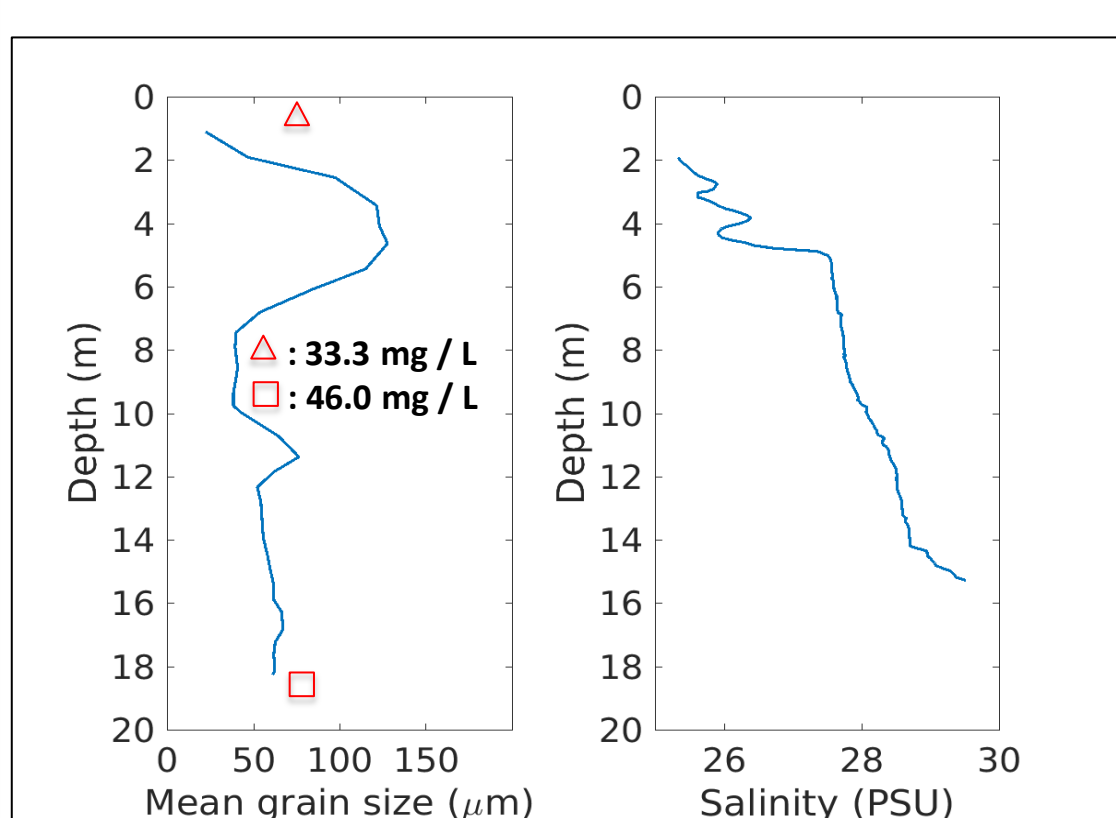


Figure 2. b) The mean grain size distribution, suspended sediment concentration and salinity profiles were measured at CW. The background grain size is silt, and a sand layer was observed at approximately 4 m. A significant salinity gradient was observed at this depth.

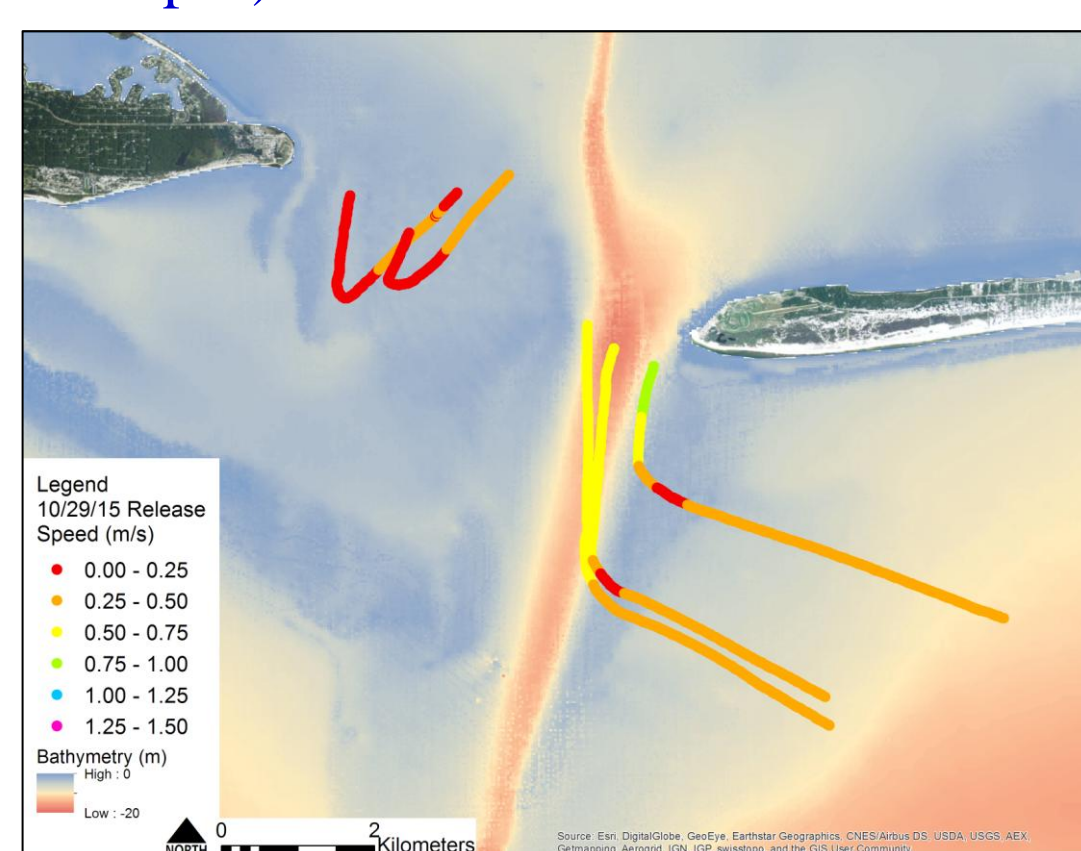


Figure 2. c) Advection in Mobile Shipping Channel was similar during slack flow and ebb flow. Generally, advection velocity of plume waters was observed to be directly proportional to the bathymetry.

SPM Algorithm Workflow

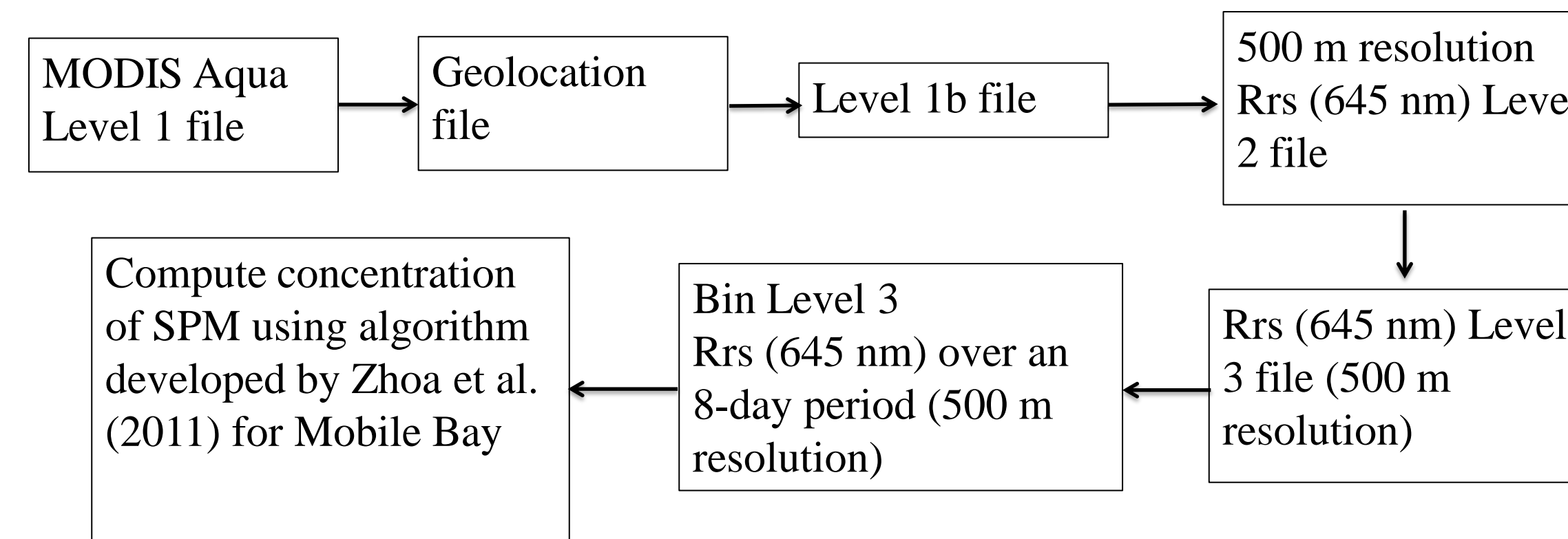


Figure 3. a) Workflow for generating Level 3 Rrs (645 nm) files using SeaDAS and estimating the concentration of SPM.

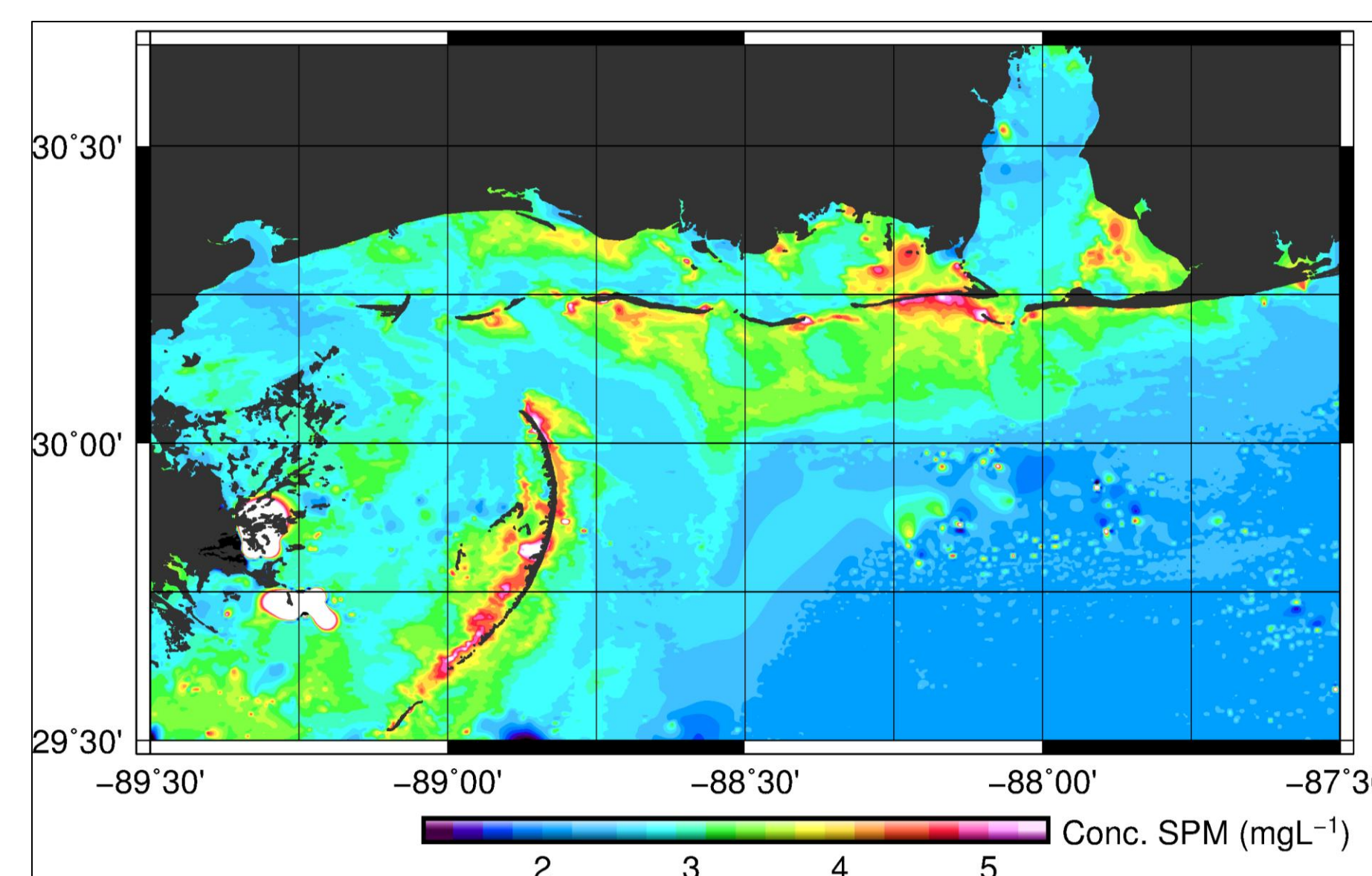


Figure 3. b) Concentration of SPM was estimated for the period corresponding to the sampling at Main Pass (10/24/2015 - 10/31/2015) using an algorithm developed by Zhao et al. (2011). Increased SPM concentration observed at Main Pass and the tidal passes indicates an increase in estuarine outflow associated with increased precipitation between 10/25 - 10/27/2015. The SPM distribution is strongly affected by Hurricane Patricia's weather system. The scenario is that waters were driven shoreward (Figure 2a), then fresher water with particulate loads emptied out of estuaries on to the MS Bight. This is evident in the plumes that appear in the SPM distribution.

Quantitative Analysis

The SPM concentration at Pass aux Herons in 2012 (01/01 - 12/31) was estimated using Zhao et al. (2011) algorithm. The SPM concentration was correlated with meteorological and oceanographic data from several sources (figure 4 a) at 0 lag.

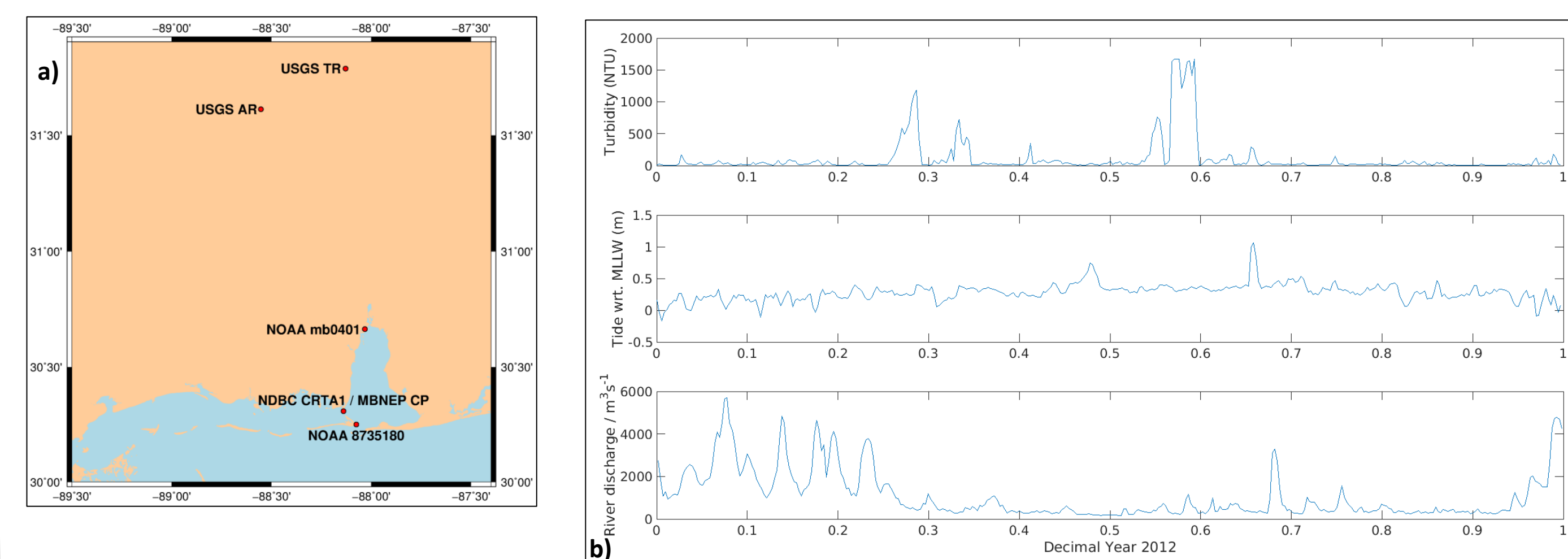


Figure 4. a) Location of USGS (river discharge), NOAA PORTS (current speed), Mobile Bay National Estuary Program (turbidity), National Data Buoy Center (wind) and NOAA NOS (water levels) sensors. b) and c) 2012 time series of the sensors listed above.

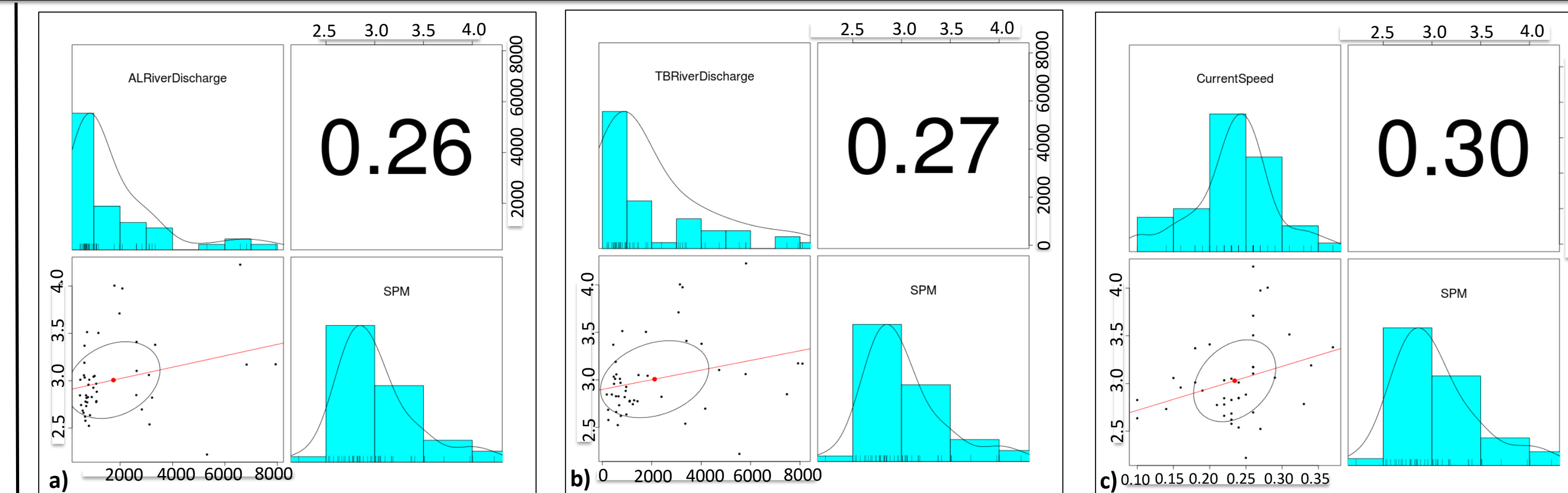
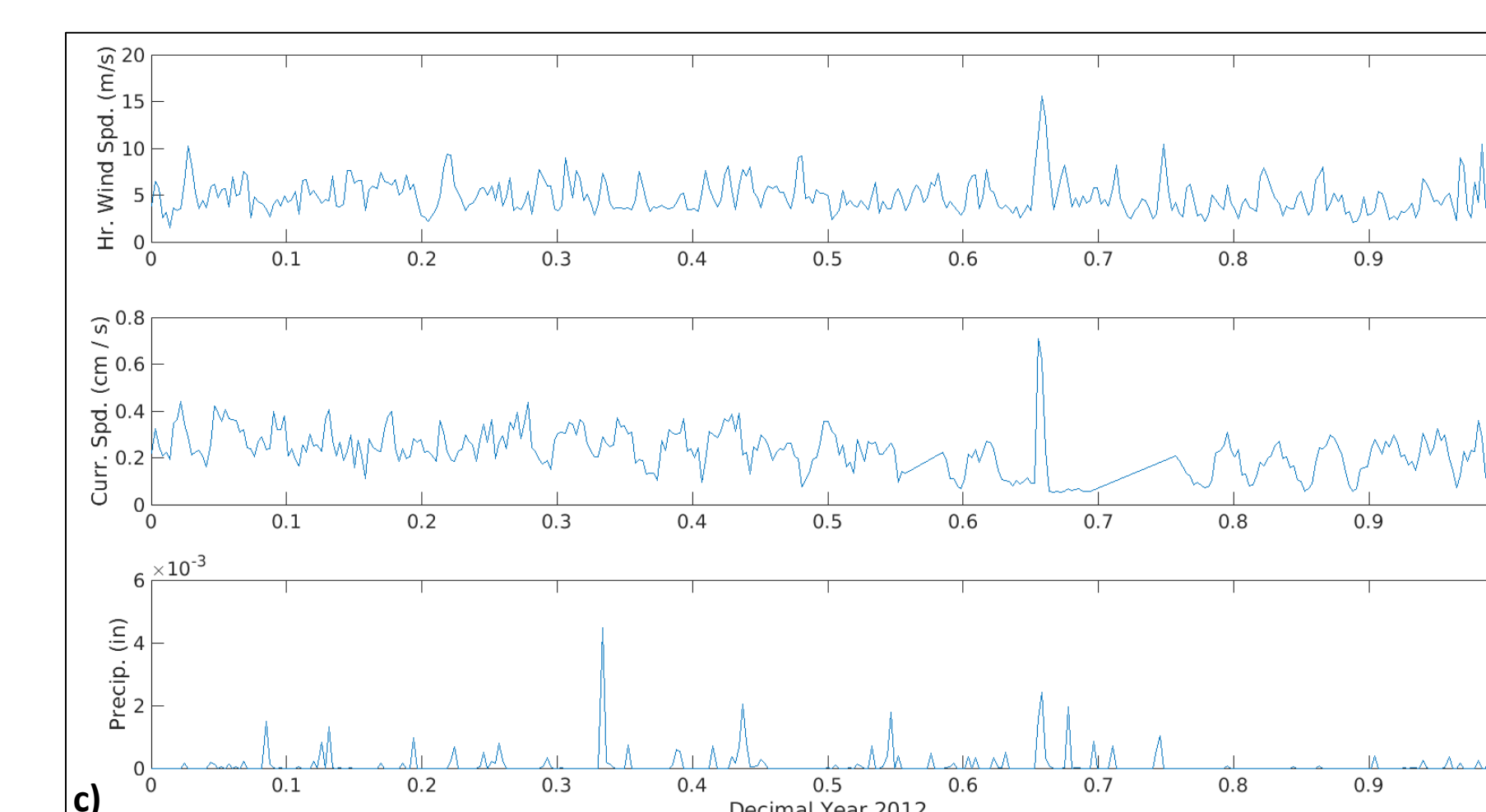


Figure 5. a) The correlation between SPM and the Alabama River discharge was not significant. It takes approximately 5 to 10 days for Alabama / Tombigbee River to exit through Pass aux Herons.

Figure 5. b) The correlation between SPM and the Tombigbee River discharge was similar to SPM / Alabama River correlation.

Figure 5. c) The correlation between SPM and current speed was not significantly different from the Alabama River / Tombigbee River discharge.

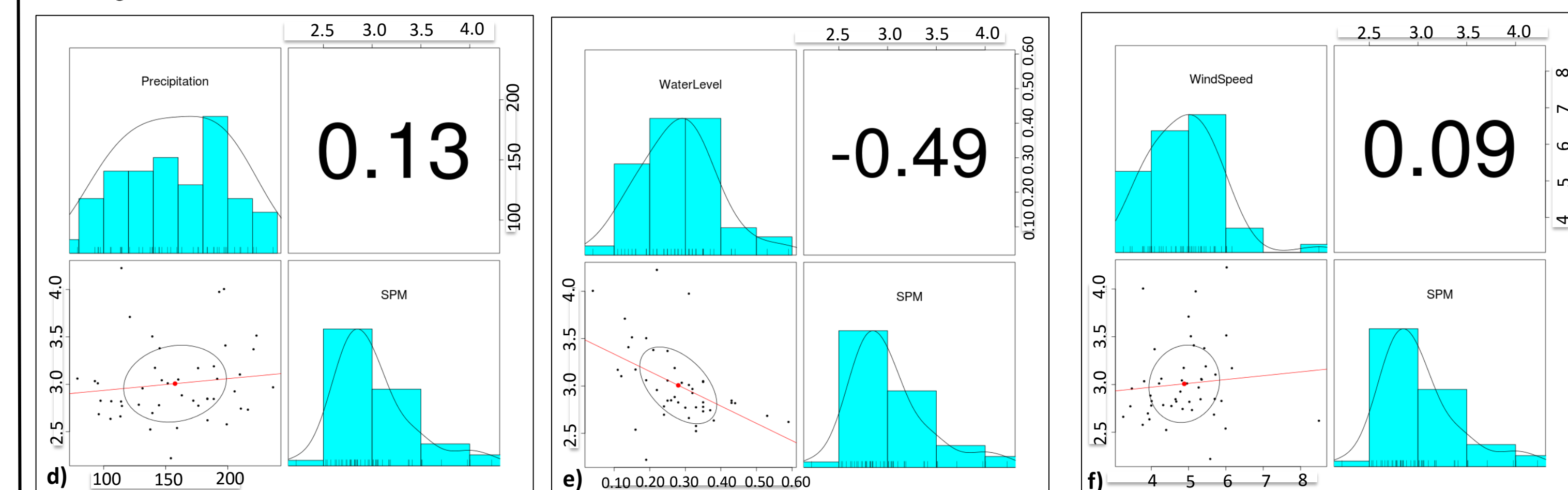


Figure 5. d) The correlation between SPM and the precipitation was not significant. Precipitation may contribute indirectly to SPM via increased river discharge.

Figure 5. e) The SPM and water levels had the highest correlation. The period of the neap / spring tidal cycle is approximately 14 days. An 8-day period (SPM temporal resolution) is close to a factor (7) of 14. This may be one reason for the high correlation between SPM and water levels.

Figure 5. f) Wind was expected to have a more significant effect on SPM. The depth at Pass aux Herons is less than 5 m. At a specific threshold wind speed the sediments will be suspended due to the shallow bathymetry. An increase in wind speed beyond the threshold will not result in an increase in the concentration of suspended sediments.

Conclusion

Initial results suggest the following:

- Changes in the grain size distribution with depth are associated with the salinity gradient.
- Cold fronts and tropical systems can flush fresher estuarine waters onto the MS Bight, leading to pronounced patchiness in SPM.
- The high SPM and water level correlation may be the result of the 7 day spring / neap tidal cycle. The difference between high and low water is maximum at spring tide. The constricted nature of Pass aux Herons results in the velocity of the water exiting Mobile Bay during ebb tide via Pass aux Herons to increase. The concentration of SPM is directly proportional to the velocity of the exiting water mass.

Future Work

- In situ data (LISST and water samples) will be collected in MS Sound in spring and summer.
- Mid depth water samples will be collected to measure grain size distribution and suspended sediment concentration.
- Calculate the cross correlation for a region located in central Mobile Bay. Analyze higher frequency data (i.e. turbidity) instead of 8-day binned SPM.
- Compute cross correlation at different lag times.
- Compute a multiple linear regression for turbidity / SPM using a longer time series.

References

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- Zhao, H., Q. Chen, N.D. Walker, Q. Zheng & H.L. Mac Intyre. (2011). A study of sediment transport in a shallow estuary using MODIS imagery and particle tracking simulation. *International Journal of Remote Sensing*, 32 (21): 6653-6671.

Acknowledgements

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