Analyzing wetland change along the Louisiana Coast during a period of rapid sea-level rise

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OVERVIEW

The Louisiana Coast has faced rapid sea-level rise (>10 mm/yr) since 2010 (Dangendorf et al., 2023), which can affect ecosystems along the coast and thus their functions to communities as barriers and mitigators of flood risks. The CRMS project has provided immense data (e.g., water level, vegetation type, and surface elevation change) in wetland locations all along the Louisiana coast. However, many of these data sets require in-person field measurements, which may only occur a few times a year. Additionally, the stations only represent one coordinate location. This project looks at select CRMS sites (Fig. 1) using Landsat and Sentinel satellite imagery from 2008 to 2021. This study provides a comparison of data obtained from remote sensing analyses to the field data and a look at the spatial area represented by the field data.

METHODS

- CRMS data (water level (WL) and surface elevation (SE) collected from project's website.
- Landsat 5 & 8 and Sentinel-2 images were analyzed in Google Earth Engine for NDVI and MNDWI.
- Time series of CRMS data are compared to MNDWI & NDVI to determine representation.
- Sentinel-2 images were analyzed in ArcGIS Pro for spatial patterns within 100 m radius of the CRMS stations.

NDVI: *index that measures health of the vegetation*
MNDWI: *index that measures water content*

LANDSAT 5 AND 8 DATA

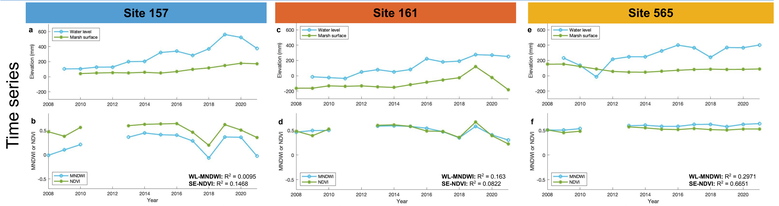

*Fig. 3: **(a, c, and e)** Time series of annual average field collected data; **(b, d, and f)** Time series of annual average MNDWI at the WL station and NDVI at the SEC station obtained from Landsat images. R^2 values represent the correlation strength between water level (WL) & MNDWI and surface elevation (SE) & NDVI.*

Site 157: MNDWI follows WLI in the field. Average tide range at station: 160 mm

Site 161: NDVI follows SE in the field. Average tide range at station: 220 mm

Site 565: NDVI follows SE in the field. Average tide range at station: 0.7 mm

Why do MNDWI and NDVI appear to follow each other in the same direction?

• Vegetation contains water • Mixed pixels • Sediment in water • 30 m resolution to big (water bodies can be < 30 m, like Site 565)

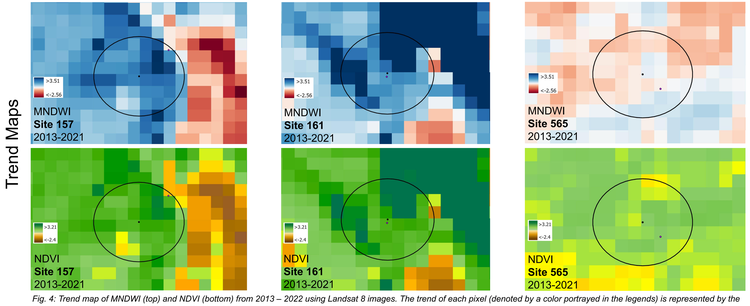

Fig. 4: Trend map of MNDWI (top) and NDVI (bottom) from 2013 – 2022 using Landsat 8 images. The trend of each pixel (denoted by a color portrayed in the legends) is represented by the slope of the time series data at that pixel. Black dot is the location of the SE station. Magenta dot is location of the WL station.

Fig. 1: Location map of CRMS sites (dots and crosses) across the Louisiana Coast used in this study. CRMS Site 157, 161, and 565 are blue, red, and yellow crosses, respectively.

Fig. 2: Aerial images of selected sites displayed. Black dot is the location of the SE station. Magenta dot is location of the WL station.

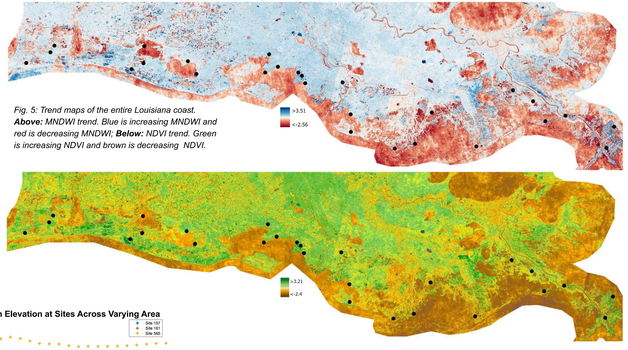

*Fig. 5: Trend maps of the entire Louisiana coast. **Above:** MNDWI trend. Blue is increasing MNDWI and red is decreasing MNDWI; **Below:** NDVI trend. Green is increasing NDVI and brown is decreasing NDVI.*

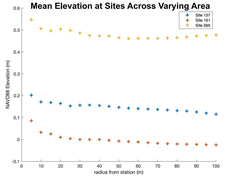

Fig. 6: Mean elevation of pixels within concentric circles at Site 157, 161, and 565 using CoNED topobathymetry from the 2021 survey. Concentric circles range from 5 m to 100 m radius in intervals of 5 m.

What role does ground elevation have?

These 3 sites show that the ground elevation at the station (located at radius 5 m) is at the highest elevation compared to the surrounding area. There are sites (not shown here) where the station is located in a depression relative to the surrounding area. These differences in ground elevation in the area may impact which wetland parts survive or drown.

SENTINEL-2 DATA

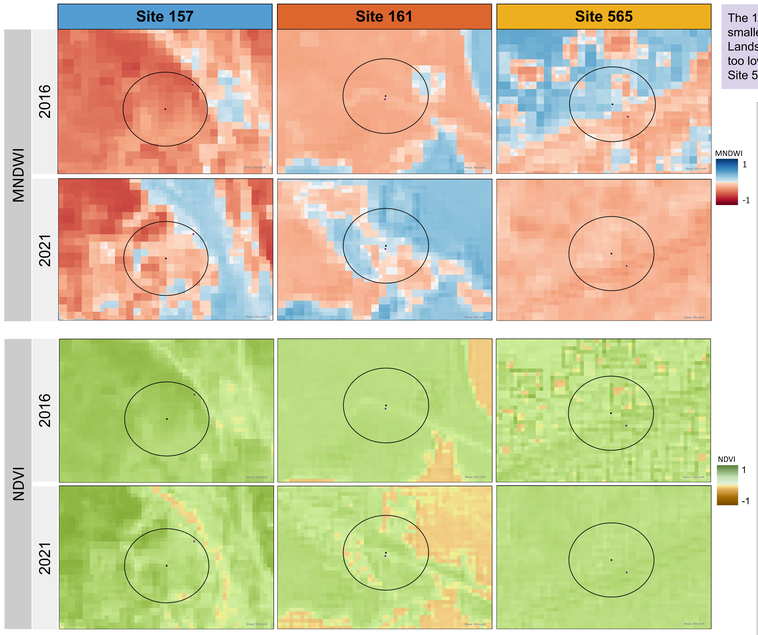

Fig. 7: MNDWI and NDVI maps using Sentinel-2 imagery from May 2016 and May 2021 for Sites 157, 161, and 565. Black outline is the 100 m radius zone that circles the SE station. MNDWI is represented as a color gradient from red (-1) to blue (+1). NDVI is represented as a color gradient from brown (-1) to green (+1). Black dot is the location of the SE station. Magenta dot is location of the WL station.

The 10 m resolution of Sentinel-2 imagery identifies smaller water bodies slightly better than the 30 m Landsat imagery. However, resolution may still be too low in some cases (e.g., the small channel in Site 565).

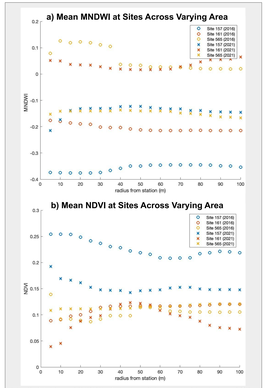

*Fig. 8: **(a)** Mean MNDWI of pixels within concentric circles at Sites 157, 161, and 565 using Sentinel-2 imagery from May 2016 and 2021. Concentric circles range from 5 m (station's pixel) to 100 m radius in intervals of 5 m. **(b)** Same as (a) for mean NDVI.*

Mean MNDWI and NDVI values vary with increasing radius for all 3 sites. Mean values also vary with time. This demonstrates how well (or not well) a single measurement can represent the greater area. This also signals how the surrounding area is changing (e.g., more/less water in the area).

CONCLUSIONS

- NDVI is better correlated to surface elevation than MNDWI is to water level elevation. Both still need to be adjusted by accounting for plant species, sediment, aquatic or floating vegetation that would affect MNDWI and NDVI pixel values.
- NDVI may be a suitable proxy for surface elevation under the assumption that vegetation staying alive (measured by NDVI) allows sediment to accumulate, thus is associated with surface elevation.
- NDVI can help track wetlands' response to changes in water.
- MNDWI can help determine if wetlands are being flooded consistently.
- We can track wetland health (especially in terms of the vegetation) more frequently than field surveys.

FUTURE WORK

- Further "calibrate" remote sensing data to represent field data, which includes accounting for sediment, aquatic vegetation, and other factors influencing mixed pixels.
- Extend data to pre-2008 (if field data is available).
- Try correlating the indices from Sentinel-2 images to field data (higher resolution may distinguish smaller water bodies better)
- Separate averages by growing season and frost season.
  - Less canopy coverage in the frost season may show more water and improve NDWI.
- Analyze the changes in the wetlands during this rapid sea-level rise and compare it to pre-rapid sea-level rise.

References:
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