Tide Gauges in Coastal Louisiana Reveal Long-term Trends More than Twenty Times the Global Average since 1950

Image: https://www.jpl.nasa.gov/

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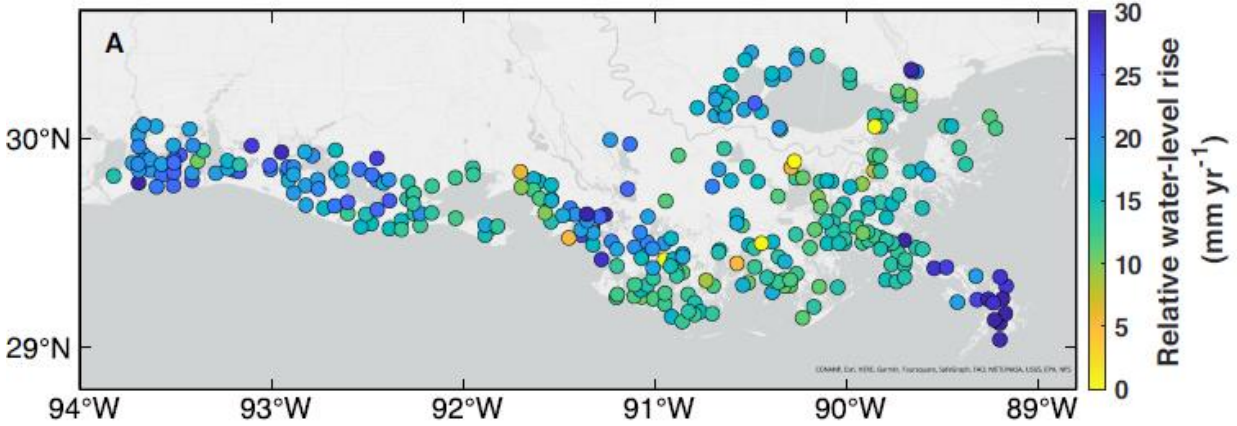
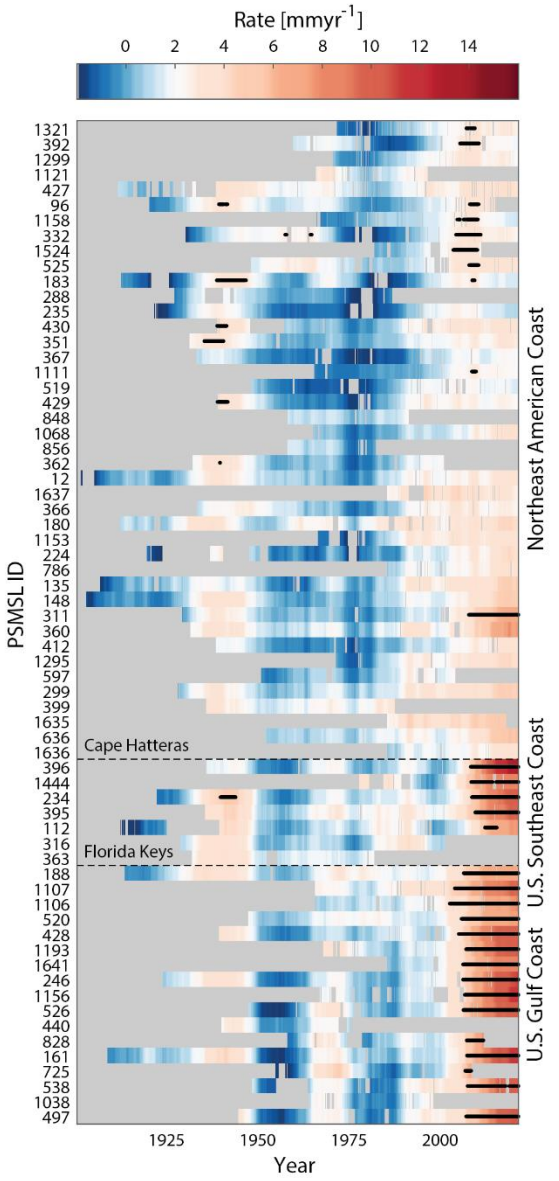
MISS DELTA

Motivation & Background

- Coastal Louisiana faces great risks due to some of the largest relative sea level rise rates worldwide and an unprecedented acceleration over the past 16 years (more impactful storm surge, land loss, etc.)
- Rate at Grand Isle tide gauge (9.7 mm/yr) typically used as representative rate
- However, there are important localized effects on these rates compared to larger Gulf of Mexico (i.e., land subsidence)



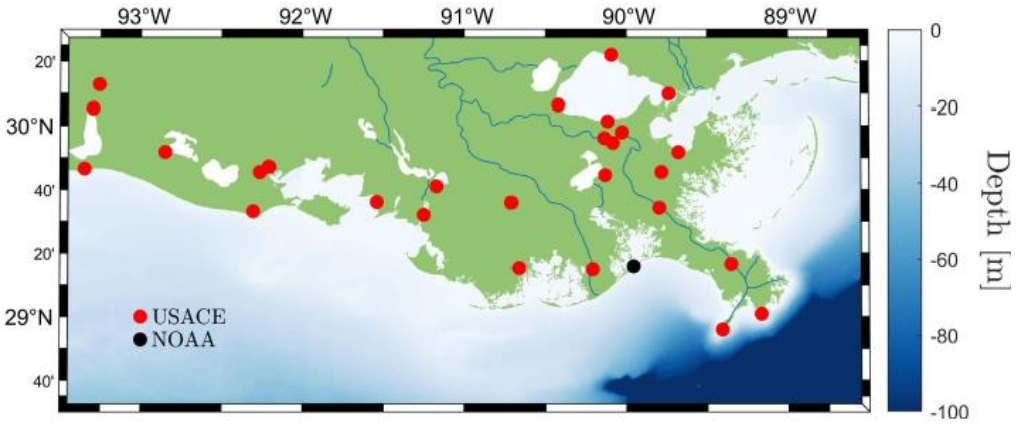
Li et al. (2024), Nature Comm.

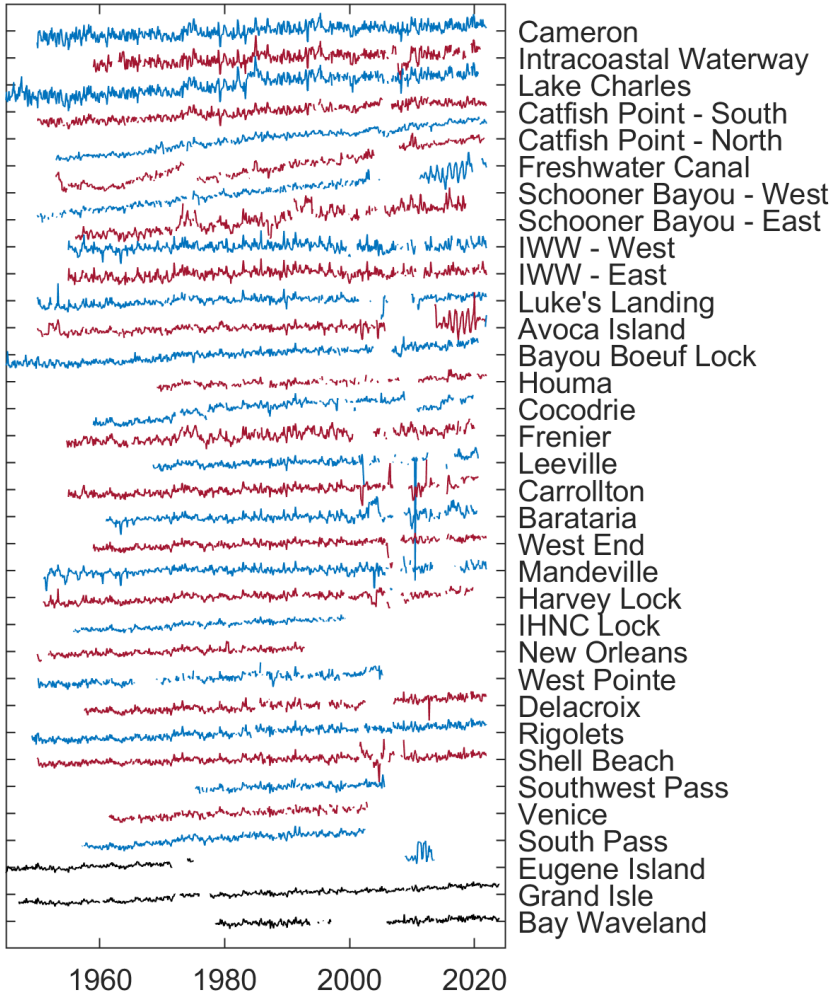


Dangendorf et al. (2023), Nature Comm.

Motivation & Background

- Previous studies are limited by number of observations & record length
- We introduce here a set of 31 tide gauges located throughout southern Louisiana maintained by the US Army Corps of Engineers (USACE), extending back to the 1950s
- Has not been analyzed before & affected by lots of unaccounted datum shifts and gaps





Objectives

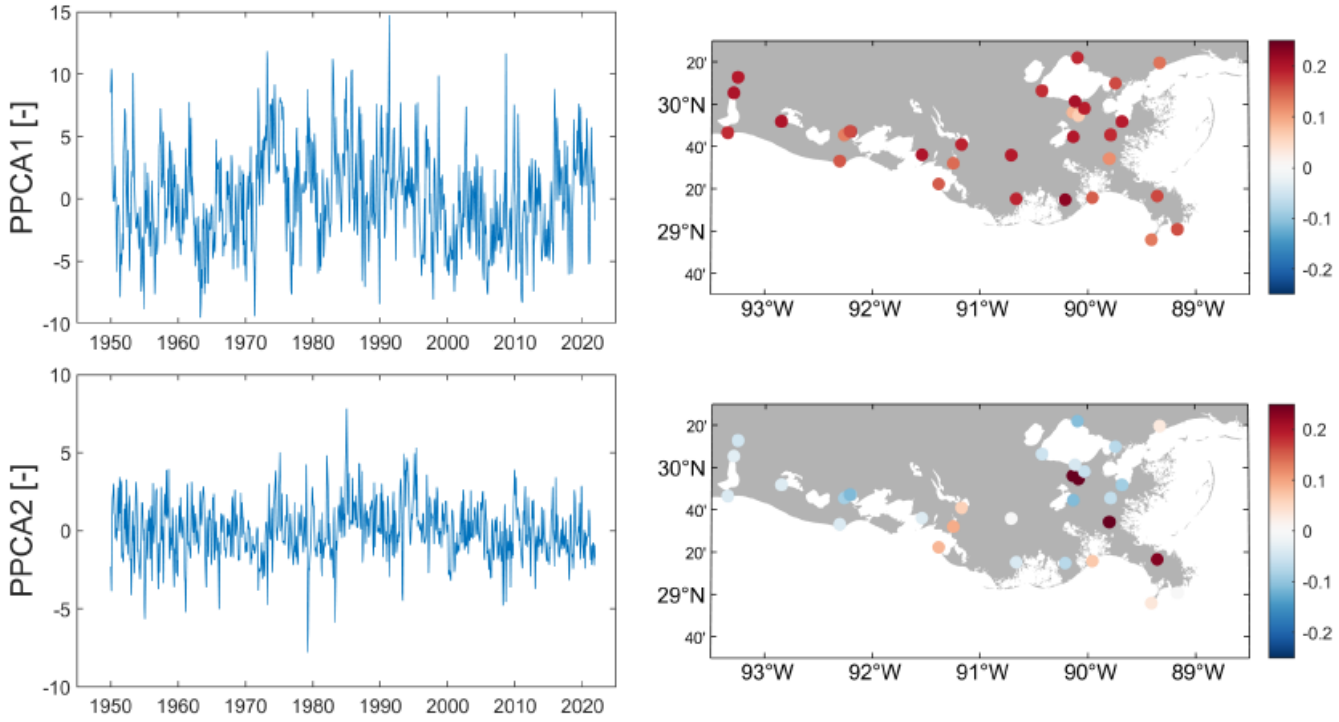
1. Develop homogenization framework to extend and correct Louisiana tide gauge records

2. Use final homogenized dataset to make robust estimates of linear and non-linear relative sea level trends

3. Attribute specific causes to the sea level trends calculated at each gauge

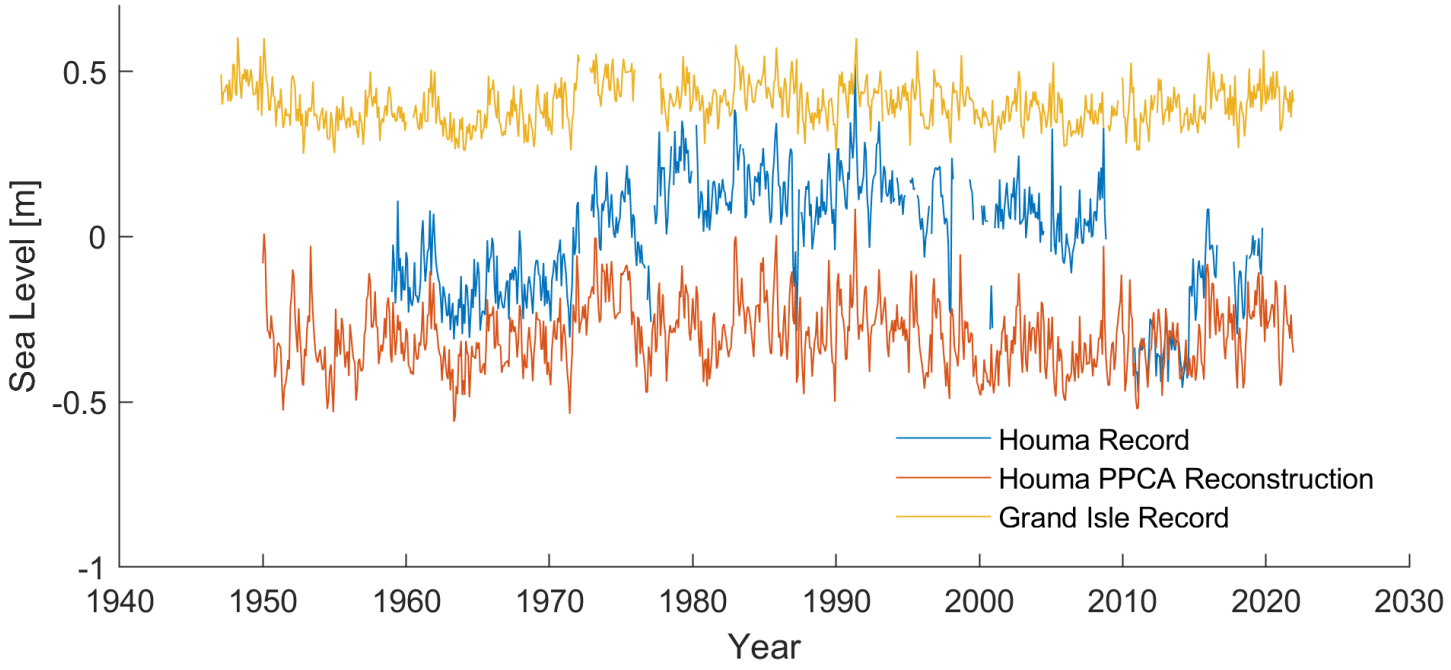
Probabilistic Principal Component Analysis (PPCA)

- PPCA identifies dominant modes of variability within set of time series when there exist missing values
- We use 31 USACE tide gauges plus 3 tide gauges from PSMSL
- Leading 2 modes explain 97.5% of variance
- Associated with physical processes (i.e., mean GoM variations, river discharge)



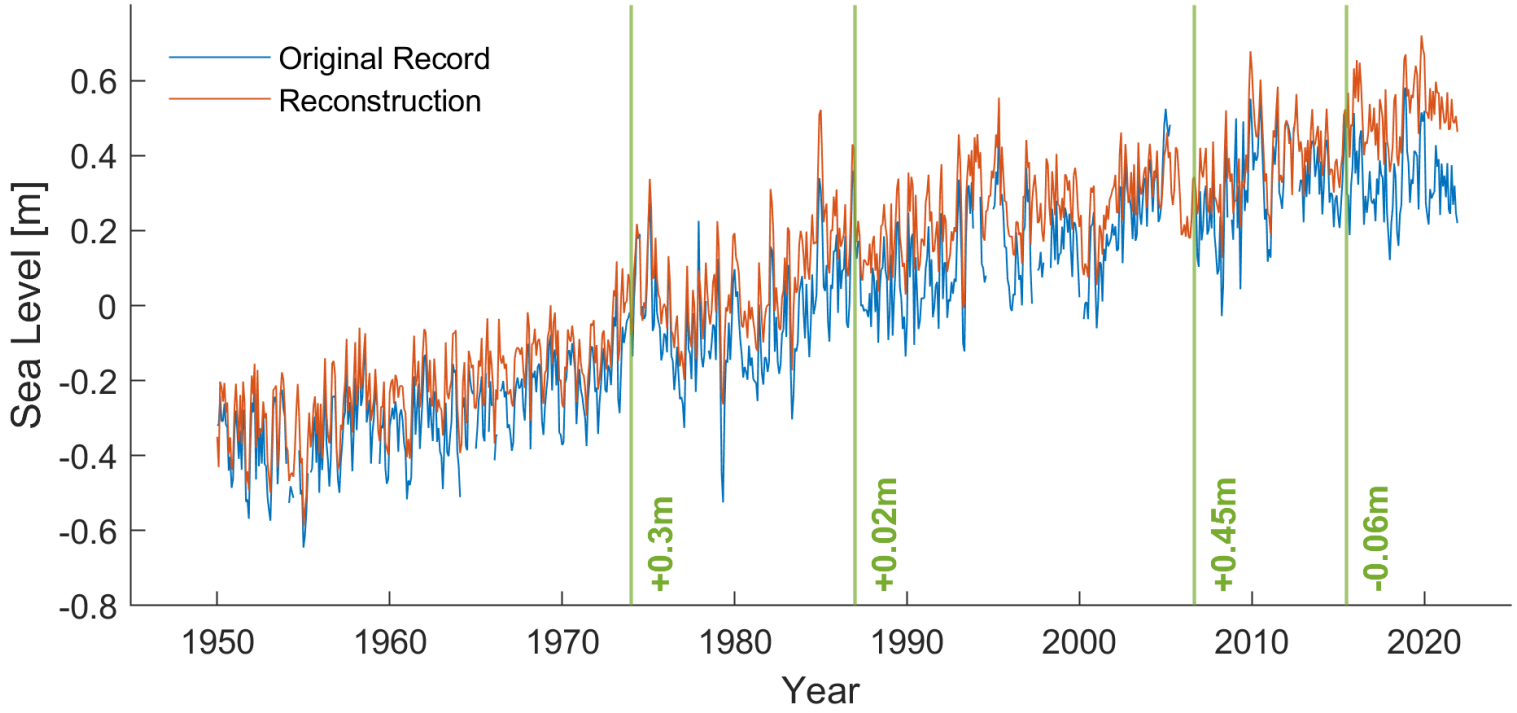
Advantages of PPCA

- We use PPCA reconstruction to find changepoints instead of buddy-checking
- Leading modes indicative of shared variability throughout the region; local errors/shifts filtered to higher order modes
- Relative contributions of these modes at each gauge captured
- Useful for gauges which are relatively isolated from other gauges
- Higher signal-to-noise ratio of residuals



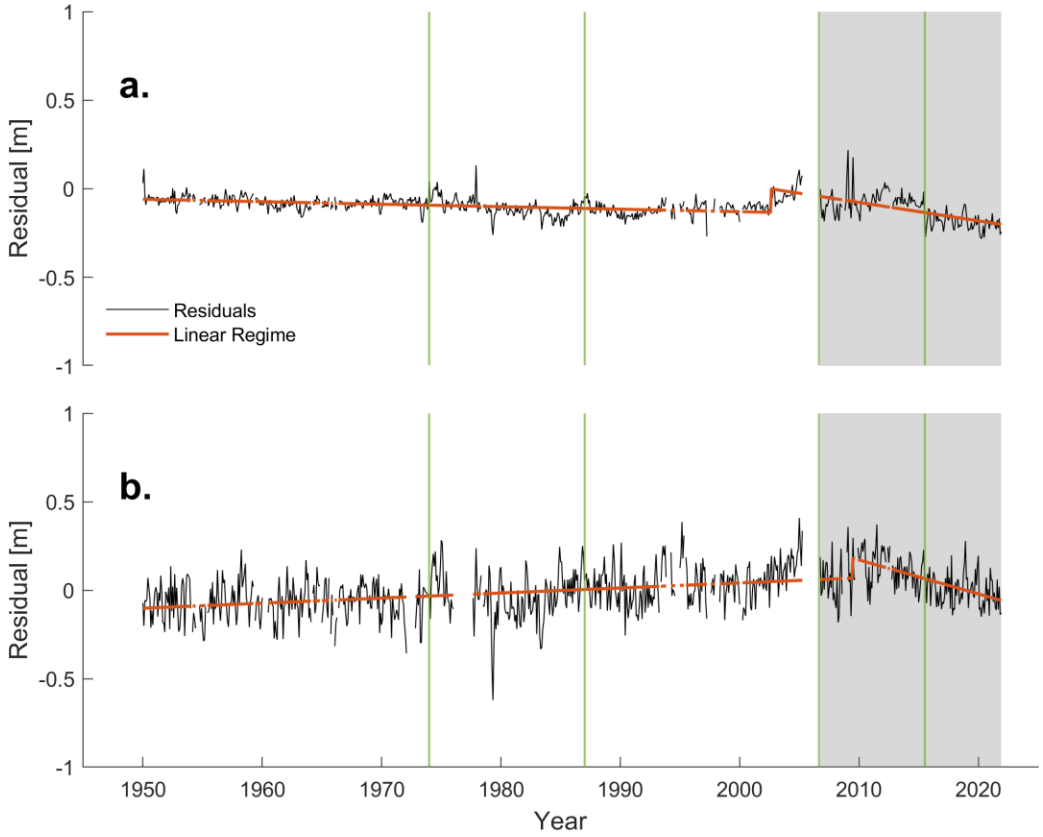
PPCA Reconstruction

- Make reconstruction from first two PPCA modes; this excludes datum shifts/local errors that would be found in higher order modes
- Most show agreement with original monthly mean tide gauge records (ex. at West Pointe a la Hache below)
- Also make note of any adjustments applied by USACE



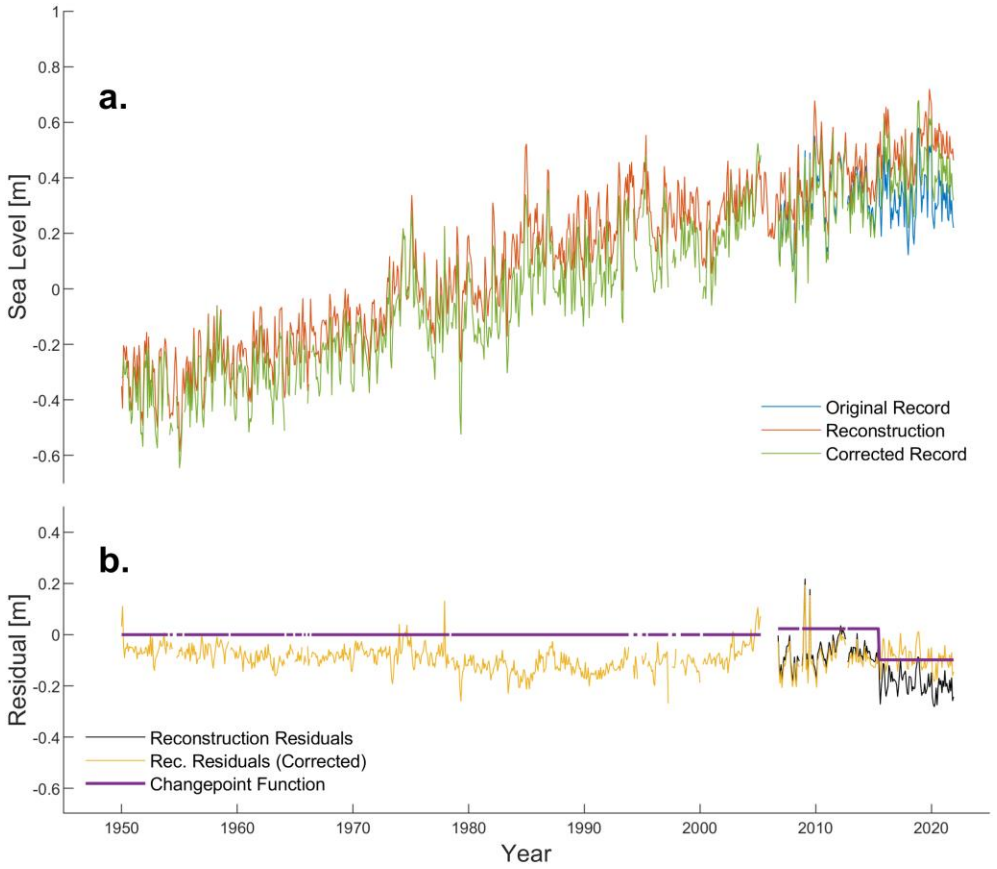
Changepoint Detection

- Use residuals **(a.)** from reconstruction and **(b.)** from Grand Isle (i.e., buddy-checking) to identify changepoints
- Use changes in linear regime detected to help pinpoint potential datum shifts
- Residuals from reconstruction have higher signal-to-noise ratio, an advantage to other studies using buddy-checking



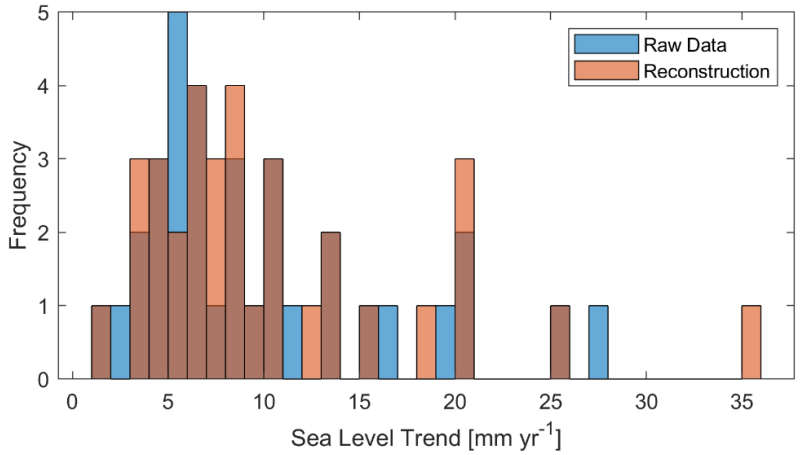
Datum Shift Corrections

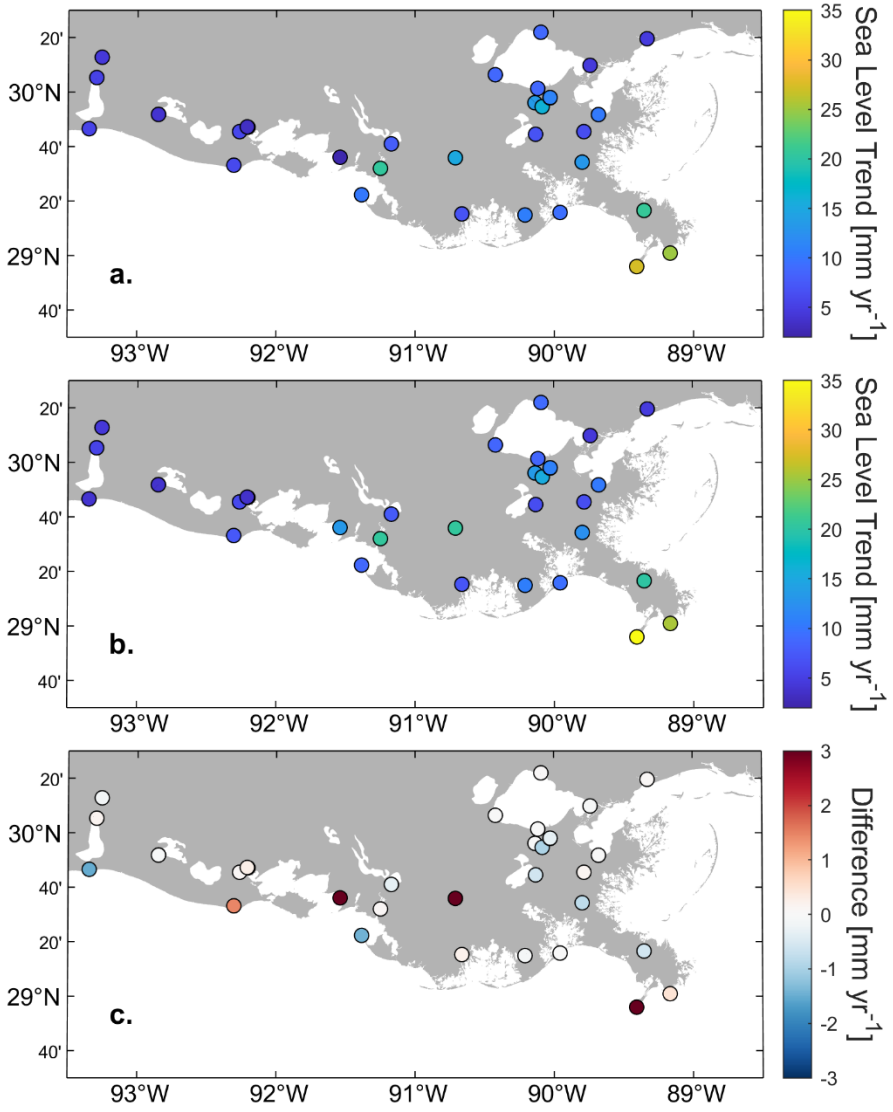
- Develop a changepoint function for each gauge (purple line) to adjust raw data based on proposed datum shifts
- In many cases, these shifts can be linked to gauge adjustments by USACE
- Process ongoing for other gauges
- We plan to communicate these proposed shifts with USACE



Homogenized Linear Trends

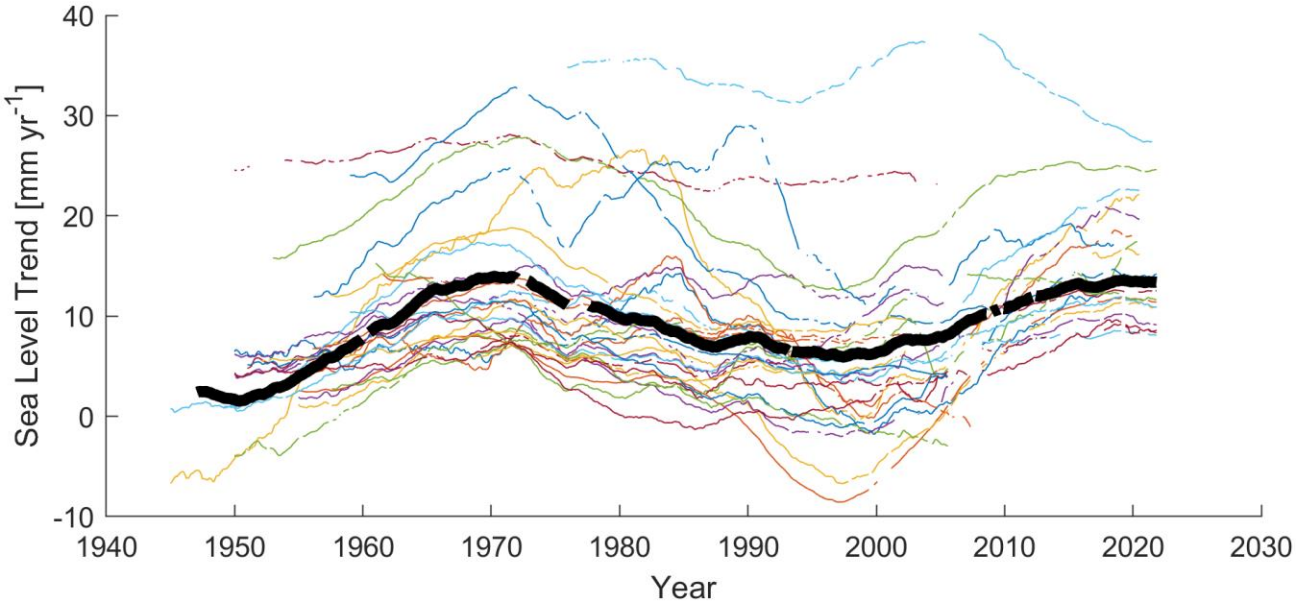
- Reconstruction also allows us to calculate robust trends for 1950 to 2021 **(Map b.)**
- Largest trend at Southwest Pass: **35 mm yr^{-1}** since 1950 – over 20 times the global mean!
- Next steps: finish homogenization and attribute causes





Non-Linear Trends

- Another advantage of PPCA reconstruction is gap-filling: can now calculate non-linear trends at each gauge using Singular Spectrum Analysis
- Short term (30-year) rates range from below **0 mm yr^{-1}** to almost **40 mm yr^{-1}**
- Much wider range than found at **Grand Isle** (thick black line)
- Clearly, local processes contribute substantially to relative sea level rise in southern Louisiana



Take-Home Messages

- PPCA can be used to homogenize large set of incomplete tide gauge records with unaccounted local errors
- Both linear and non-linear relative sea level trends vary significantly throughout southern Louisiana – using Grand Isle record alone is not enough!
- As previously found, localized processes significantly affect relative sea levels; Birdsfoot Delta in particular faces large trends
- What's next? Attributing the specific causes of these differing trends (importantly, land subsidence)

Thank you for your attention!

References

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2. Li, G., Törnqvist, T. E., & Dangendorf, S. (2024). Real-world time-travel experiment shows ecosystem collapse due to anthropogenic climate change. *Nature Communications*
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Research reported in this presentation was supported by the Gulf Research Program of the National Academies of Sciences, Engineering, and Medicine under award number SCON-10000883.

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Image: https://www.jpl.nasa.gov/news/satellites-help-scientists-track-dramatic-wetlands-loss-in-louisiana/