Cranfield
Environment
and Agrifood

Using large-scale, long-term monitoring to determine resilience in coastal wetland ecosystems

Ron Corstanje, Nikolaos Toumasis, John R. White
Dan Simms, Jim Harris

UKRI Natural Environment Research Council

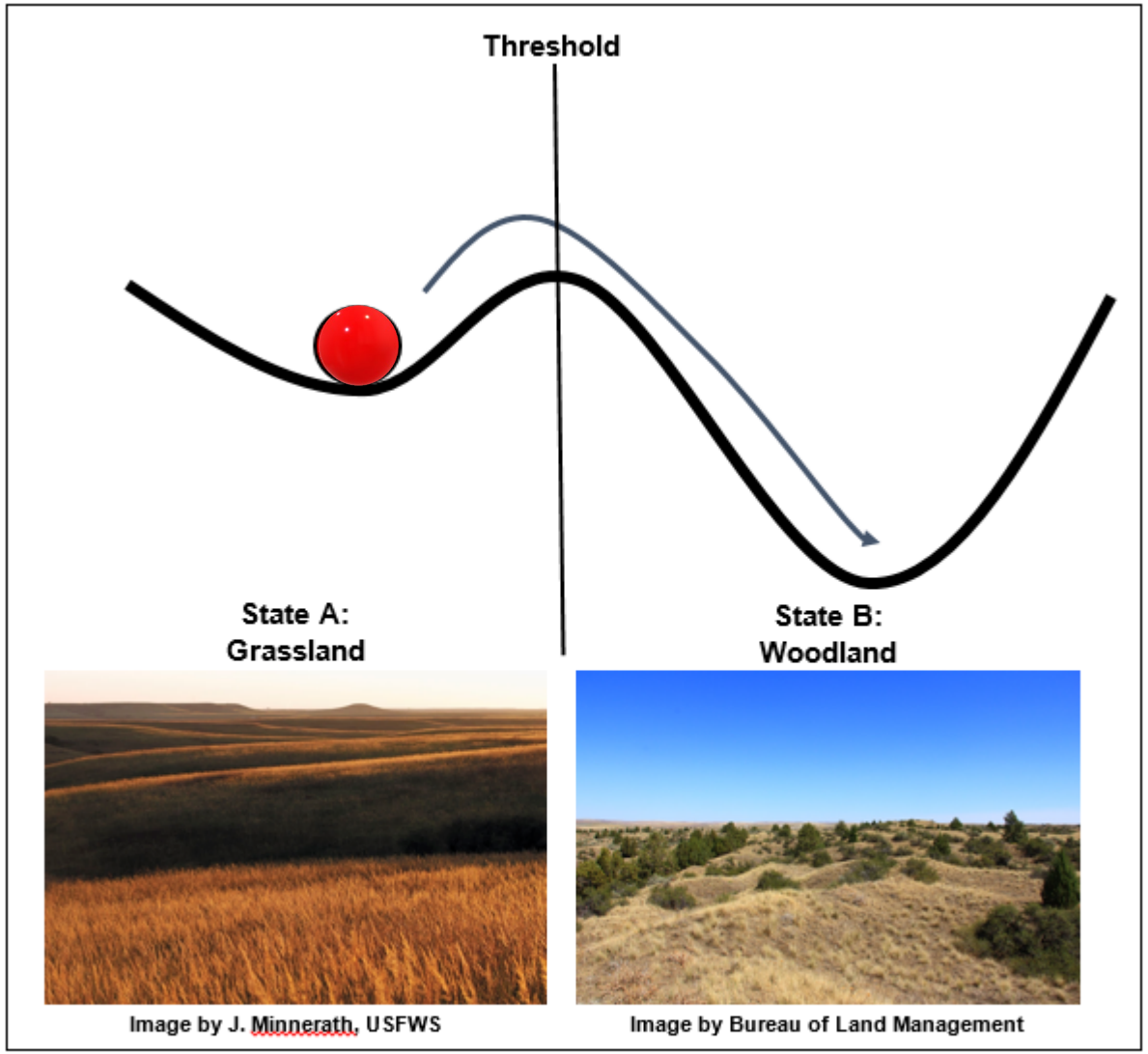
UKRI Biotechnology and Biological Sciences Research Council

www.cranfield.ac.uk

LSU College of the Coast & Environment

‘Ball and cup theory’

Cranfield Environment Centre



An example of a current **grassland state** with weak self-organizing feedbacks and low resilience (shallow cup), compared to an alternative **woodland state** with stronger self-organizing feedbacks (deeper cup).

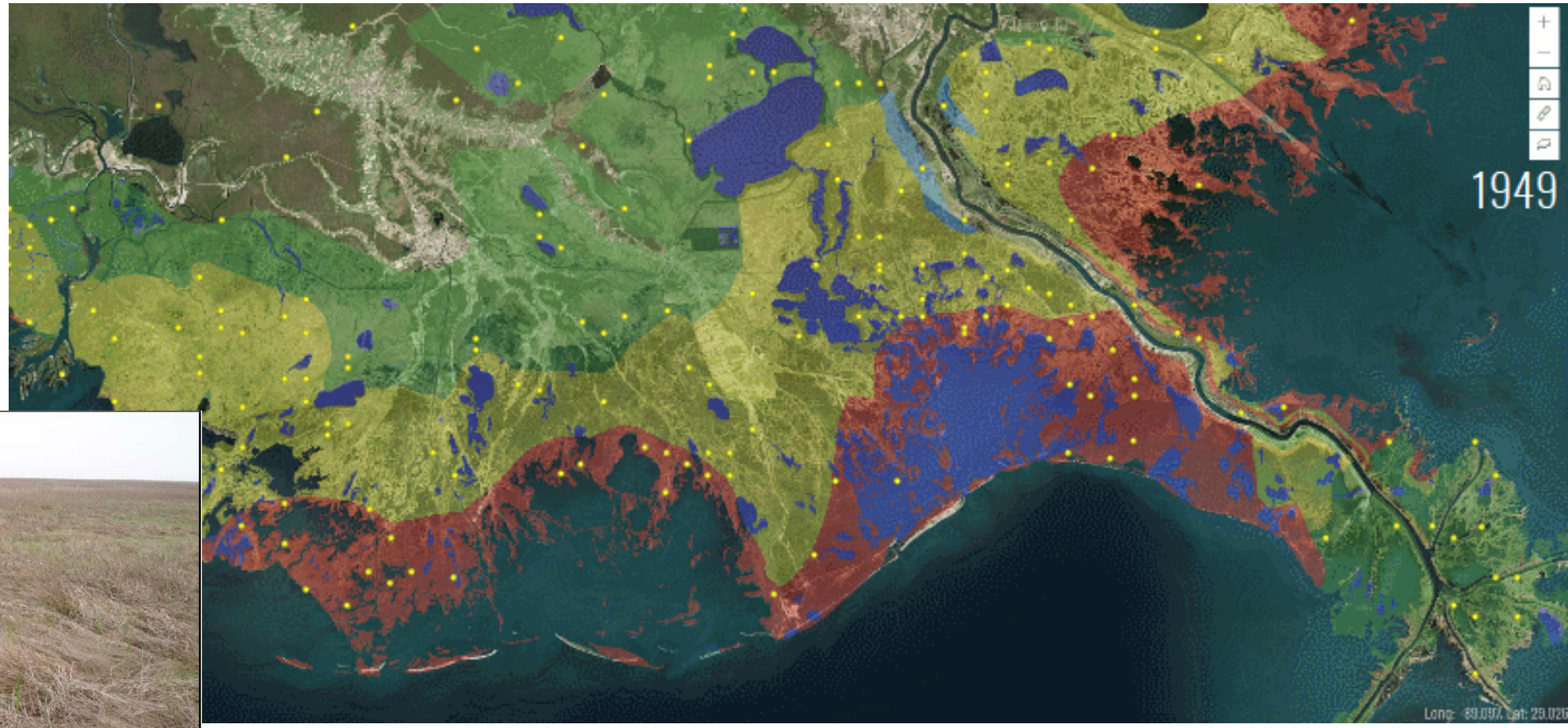
Why Resilience in Coastal Wetlands?

- To date, much research emphasis has been on wetland restoration or in better understanding the geographical place and ecological functioning of wetland ecosystems.
- However existing, functional wetlands are under significant pressures and disturbances, for example:

Mangrove degradation driven by land conversion for aquaculture and agriculture, coastal development, and pollution

Saltmarsh dieback in Cape Cod- images from the US National Park Service

The Dynamics of the Mississippi River Delta

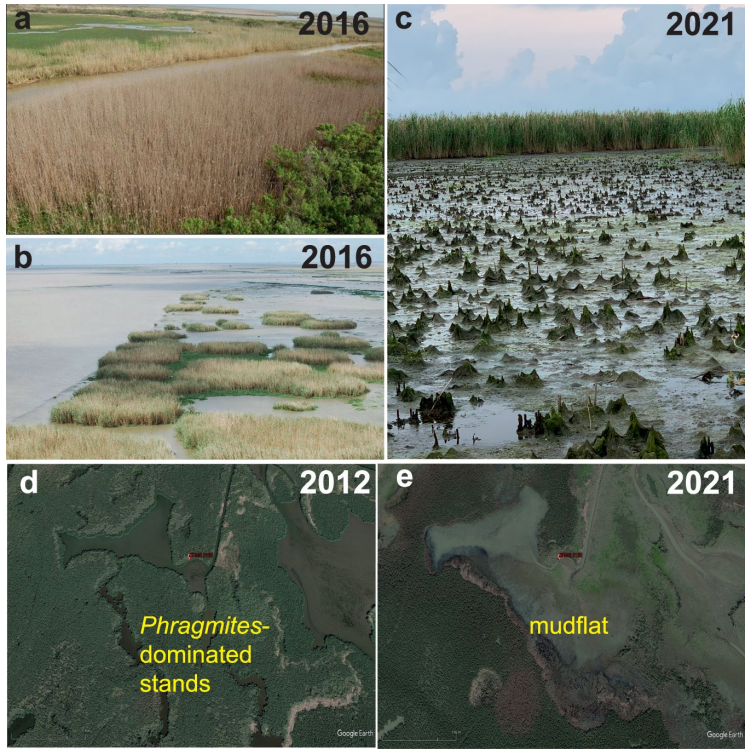


https://mississippiriverdelta.org/louisiana-is-leading-the-way-in-real-time-sea-level-rise-monitoring/vegetation-map2/

Toumasis et al., 2024 Emerging resilience metrics in an intensely managed ecological system. Ecological Engineering. https://doi.org/10.1016/j.ecoleng.2023.107151

Pressures facing the Mississippi Delta

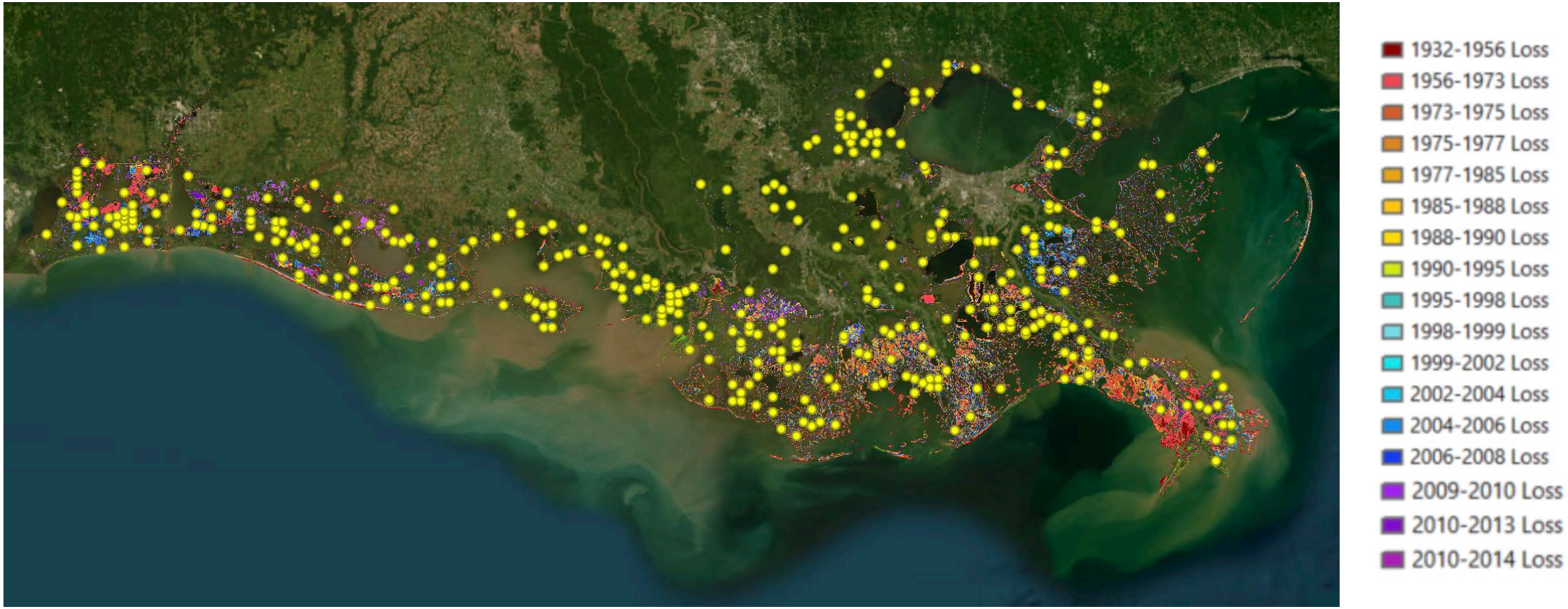
- Loss of sediment: the total amount of sediment has changed from 400 million tons to about 200 million tons per year[1,2]
- Natural disturbance events
  - Hurricanes and tropical storms
  - Drought
- Disease and other biological pressures
  - *Phragmites* loss due infestations by an invasive insects such as *Nipponaclerda b.*



[3]

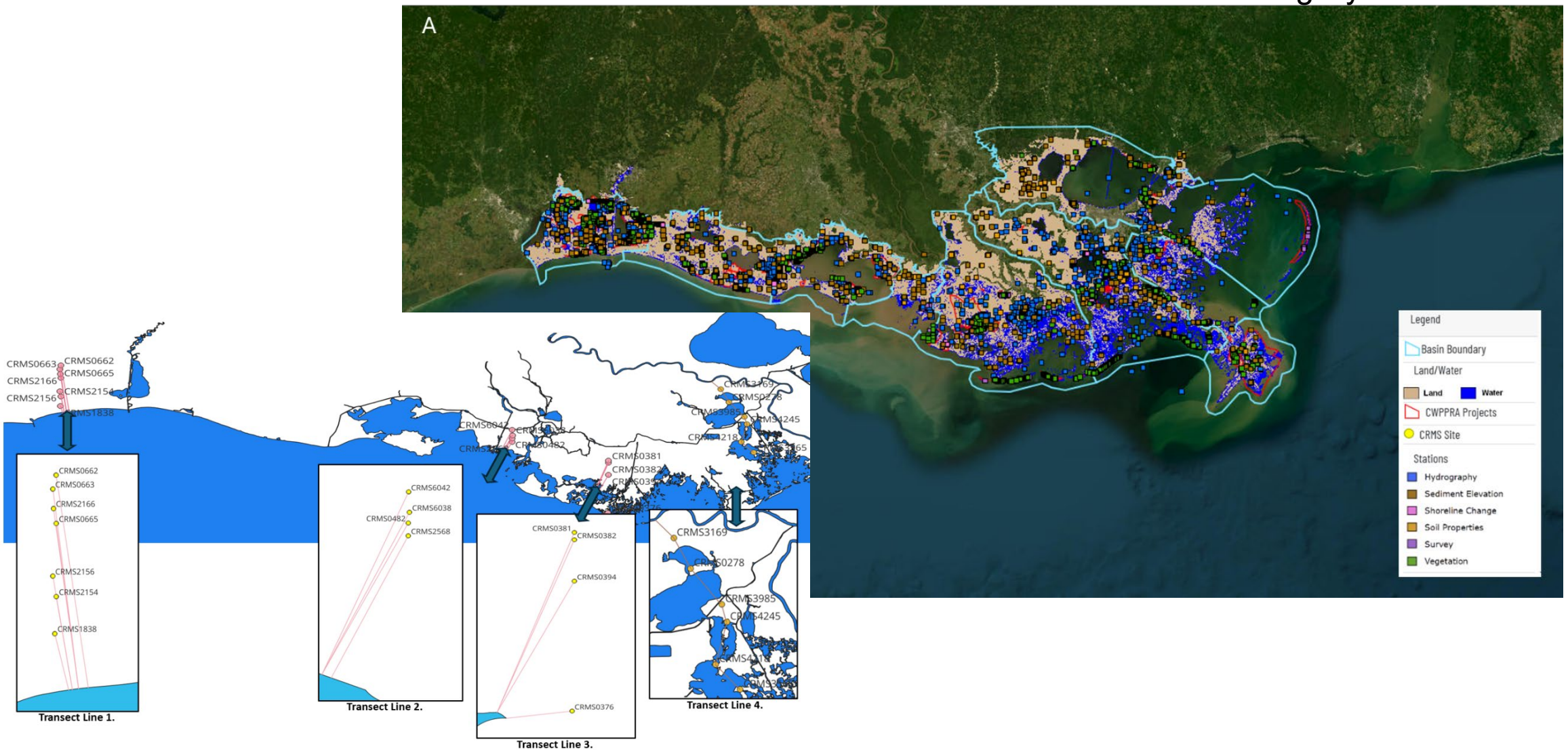
[1] Day et al., 2007. Restoration of the Mississippi Delta: lessons learned from Hurricanes Katrina and Rita. Science 315: 1679-1684. [2] Meade, R.H. and J.A. Moody. 2010. Causes for the decline of suspended-sediment discharge in the Mississippi River system, 1940-2007. Hydrological Processes 24:35-49.[3] Elsey-Quirk, T., Lynn, A., Jacobs, M.D. *et al.* Vegetation dieback in the Mississippi River Delta triggered by acute drought and chronic relative sea-level rise. *Nat Commun* **15**, 3518 (2024). https://doi.org/10.1038/s41467-024-47828-x

Coastwide Reference Monitoring System

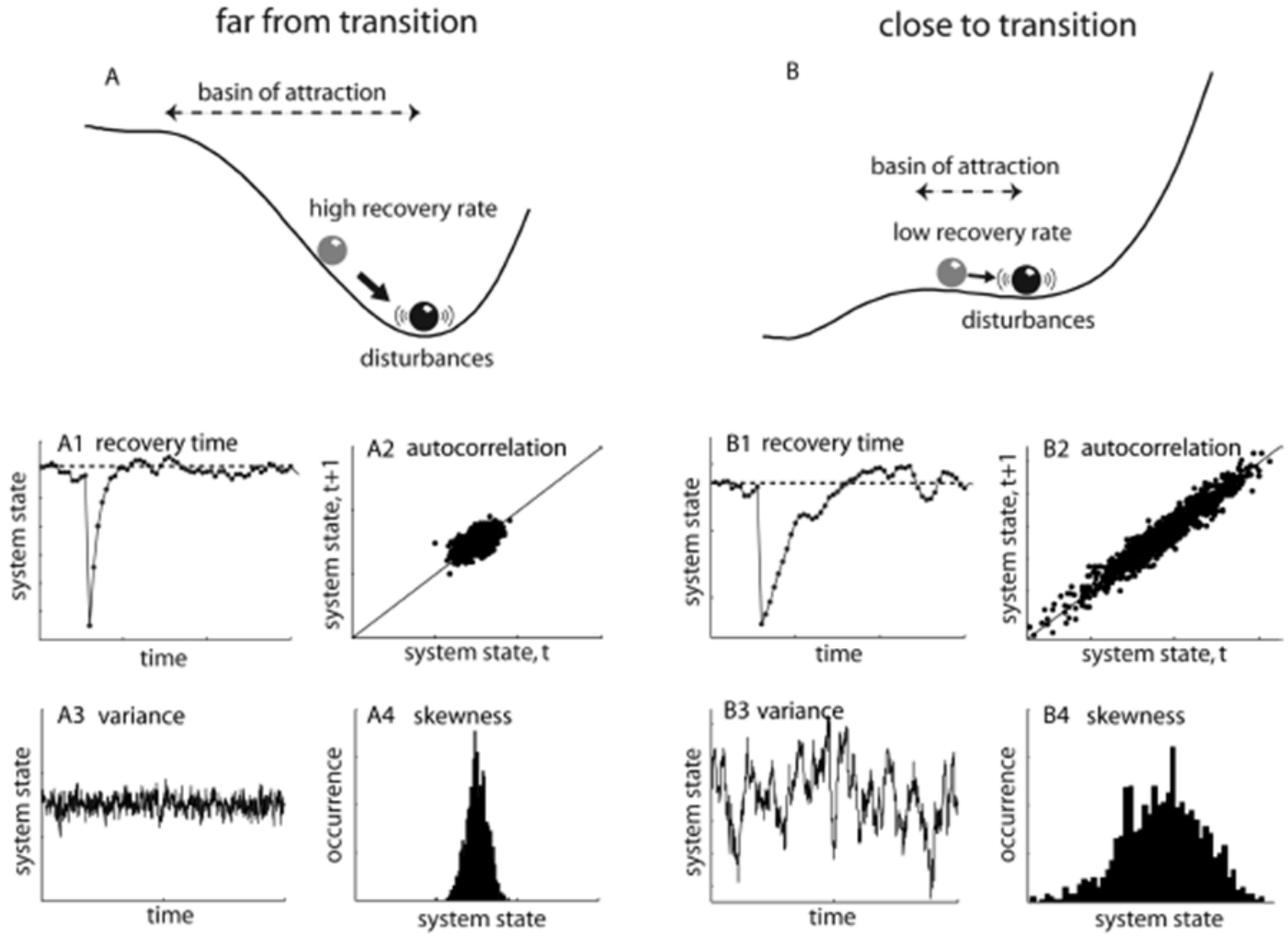


Can we use a large-scale monitoring systems to predict land loss?

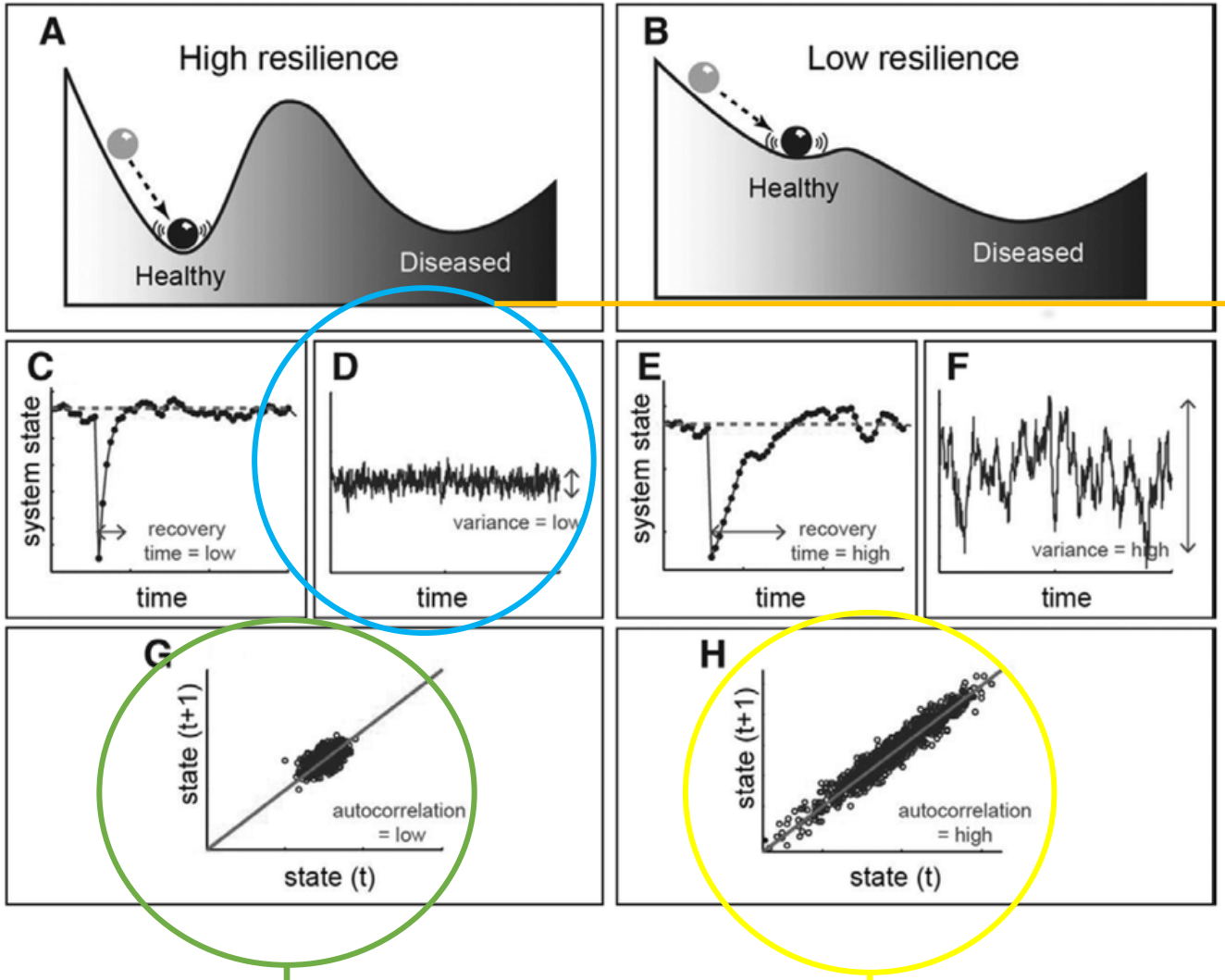
Coastwide Reference Monitoring System



Metrics of Resilience



Dakos, V. *et al.* Methods for Detecting Early Warnings of Critical Transitions in Time Series Illustrated Using Simulated Ecological Data. *PLOS ONE* **7,** e41010 (2012).



Wavelets

Variance

Rolling Autocorrelation

EWS

DLM

NDVI

Resilience

Shifts

Salinity Intrusion

STA's

Grasslands

Louisiana US

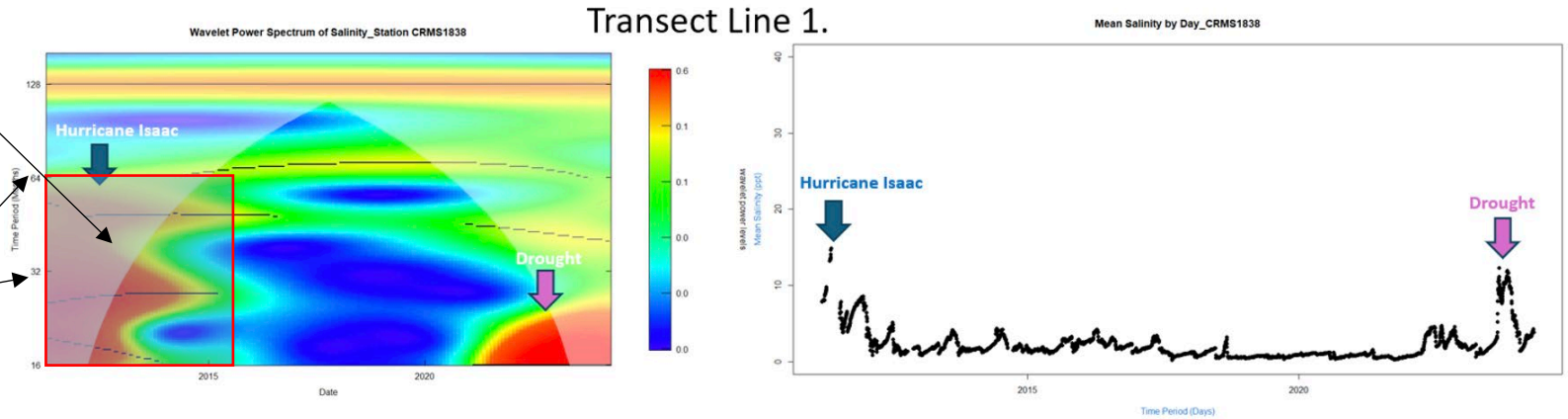
SCALE

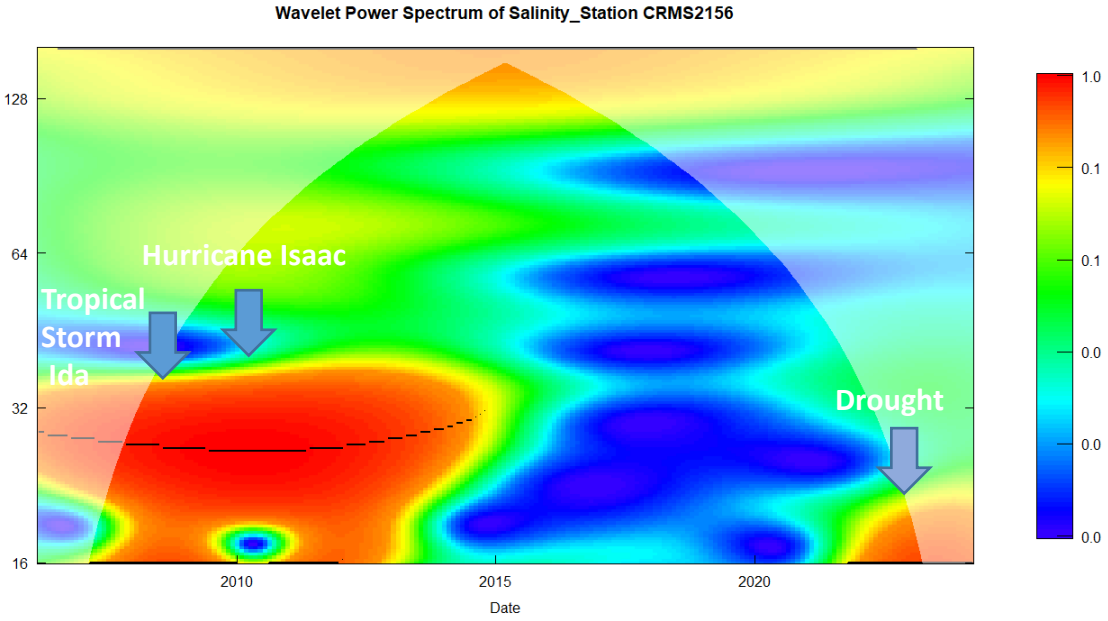
Wavelet Decomposition

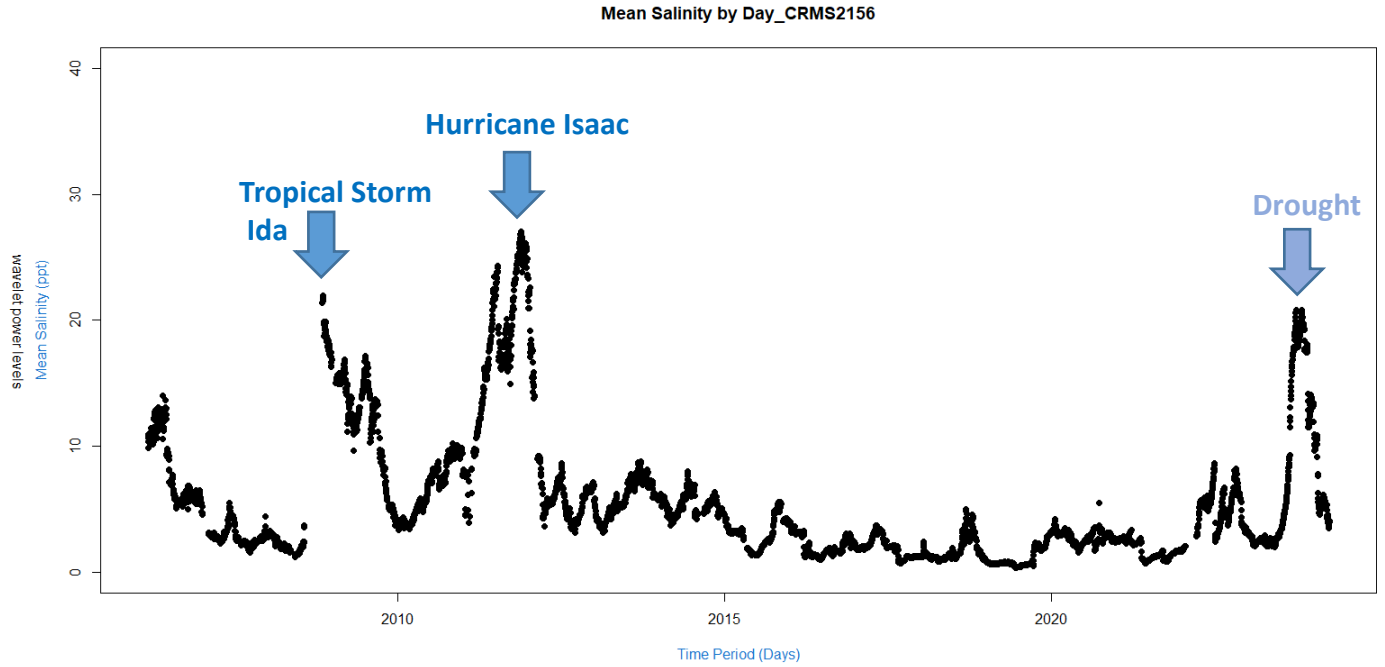
- CRMS stations was examined using Wavelet Analysis in an attempt to gauge their resistance using the "WaveletComp" R package
- The program "WaveletComp" uses a small waveform called a wavelet to determine the intensity of various periodicity lengths along any kind of continuous data—in this case, time-series data.
- The result is a power diagram that indicates (in red) the dataset's regions with the largest variance changes.

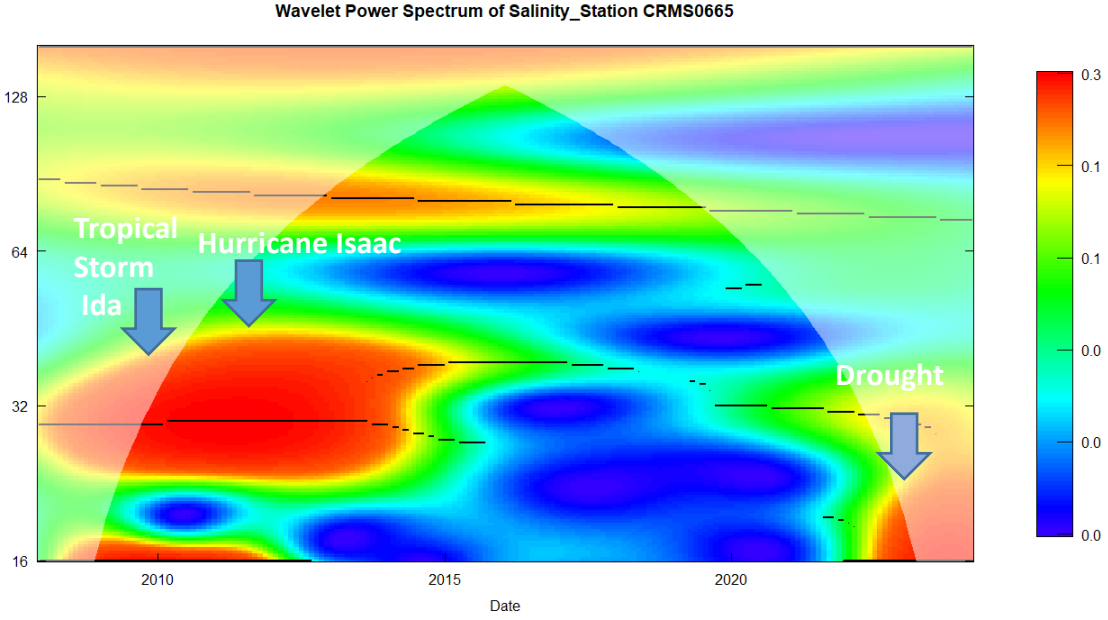
Area with relatively large variance component

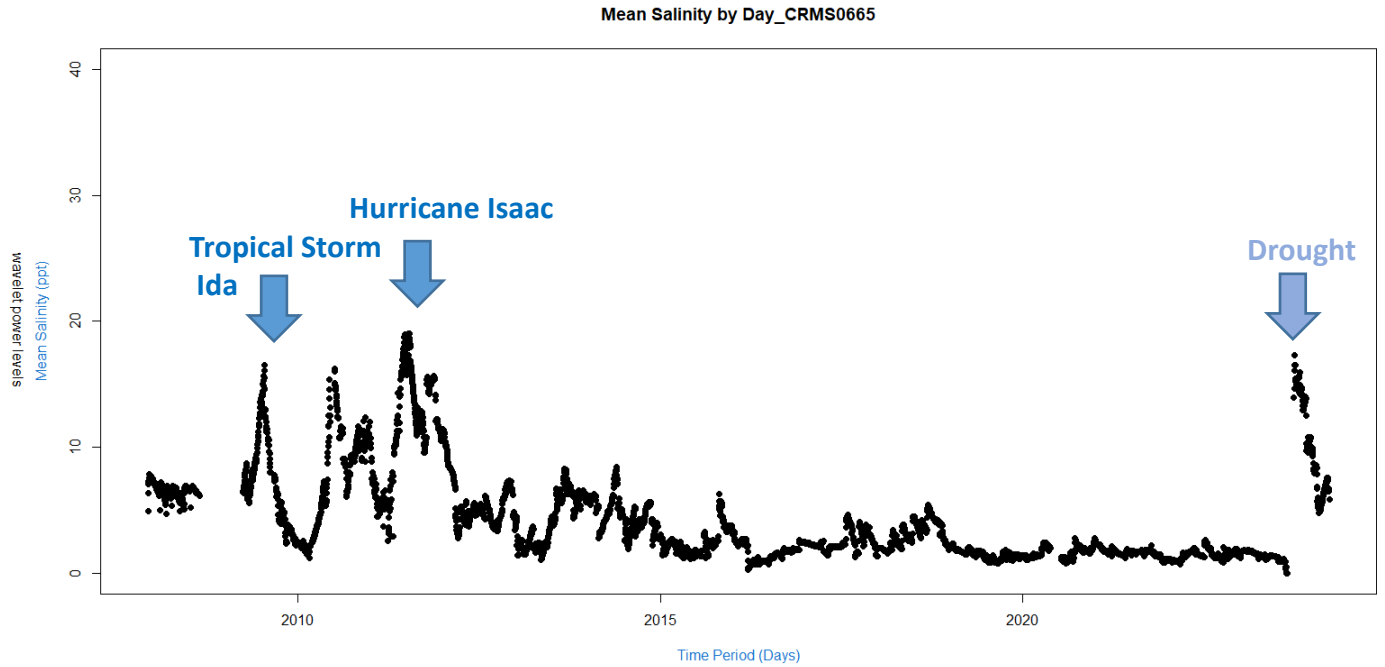
Time window (months) over which the high variance persists



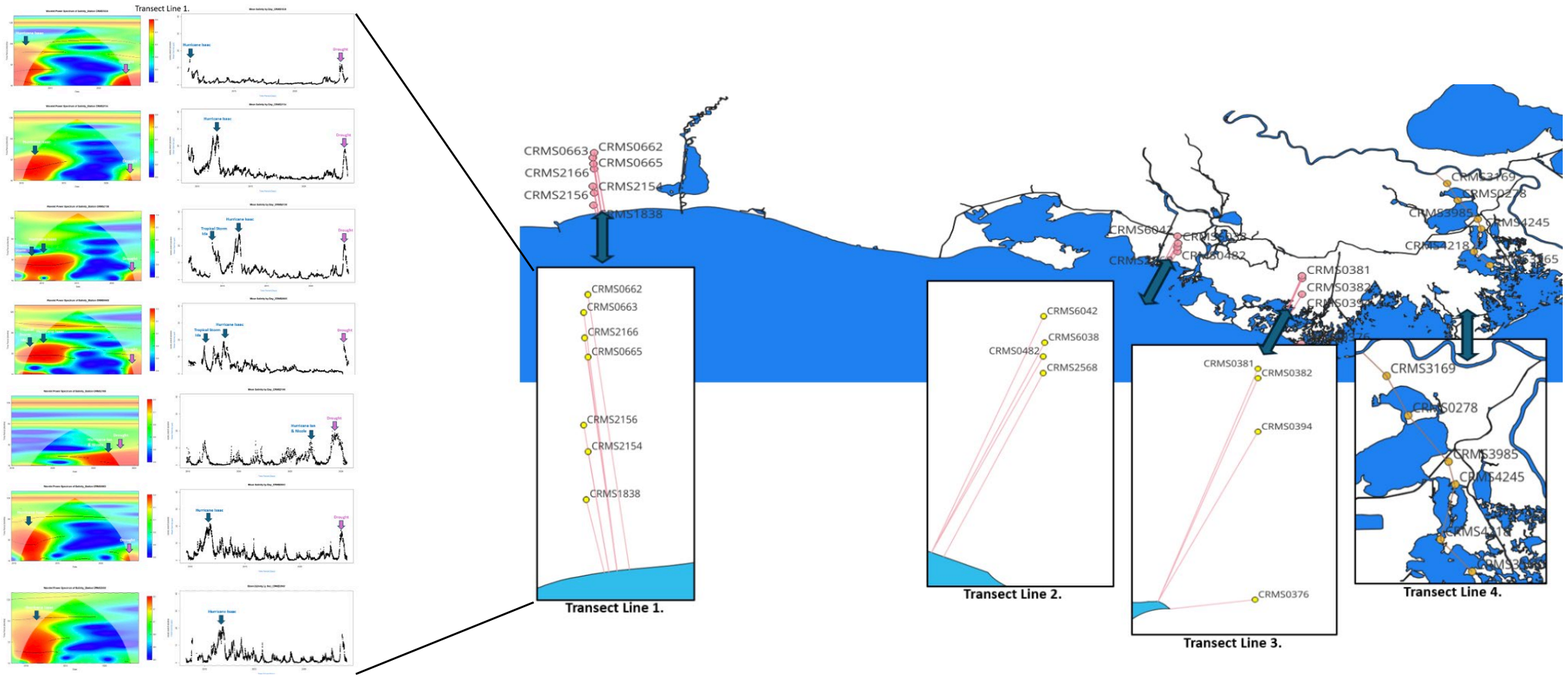

Wavelet Power Spectrum of Salinity_Station CRMS2156
128
64
32
16
2010
2015
2020
Date
Hurricane Isaac
Tropical Storm Ida
Drought
1.0
0.1
0.1
0.0
0.0
0.0


Mean Salinity by Day_CRMS2156
wavelet power levels
Mean Salinity (ppt)
0
10
20
30
40
2010
2015
2020
Time Period (Days)
Hurricane Isaac
Tropical Storm Ida
Drought

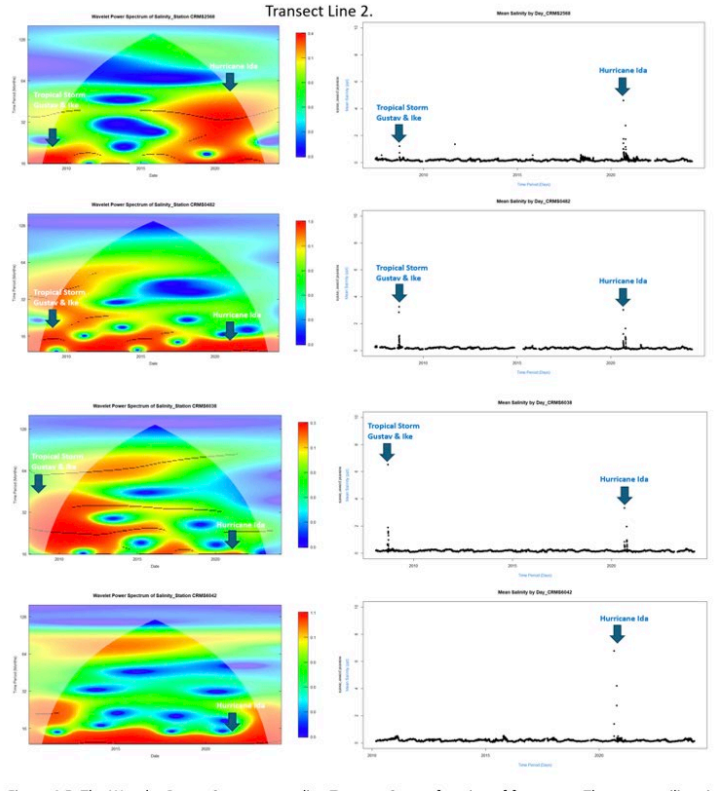

Wavelet Power Spectrum of Salinity_Station CRMS0665
128
64
32
16
2010
2015
2020
Date
Tropical Storm Ida
Hurricane Isaac
Drought
0.3
0.1
0.1
0.0
0.0
0.0

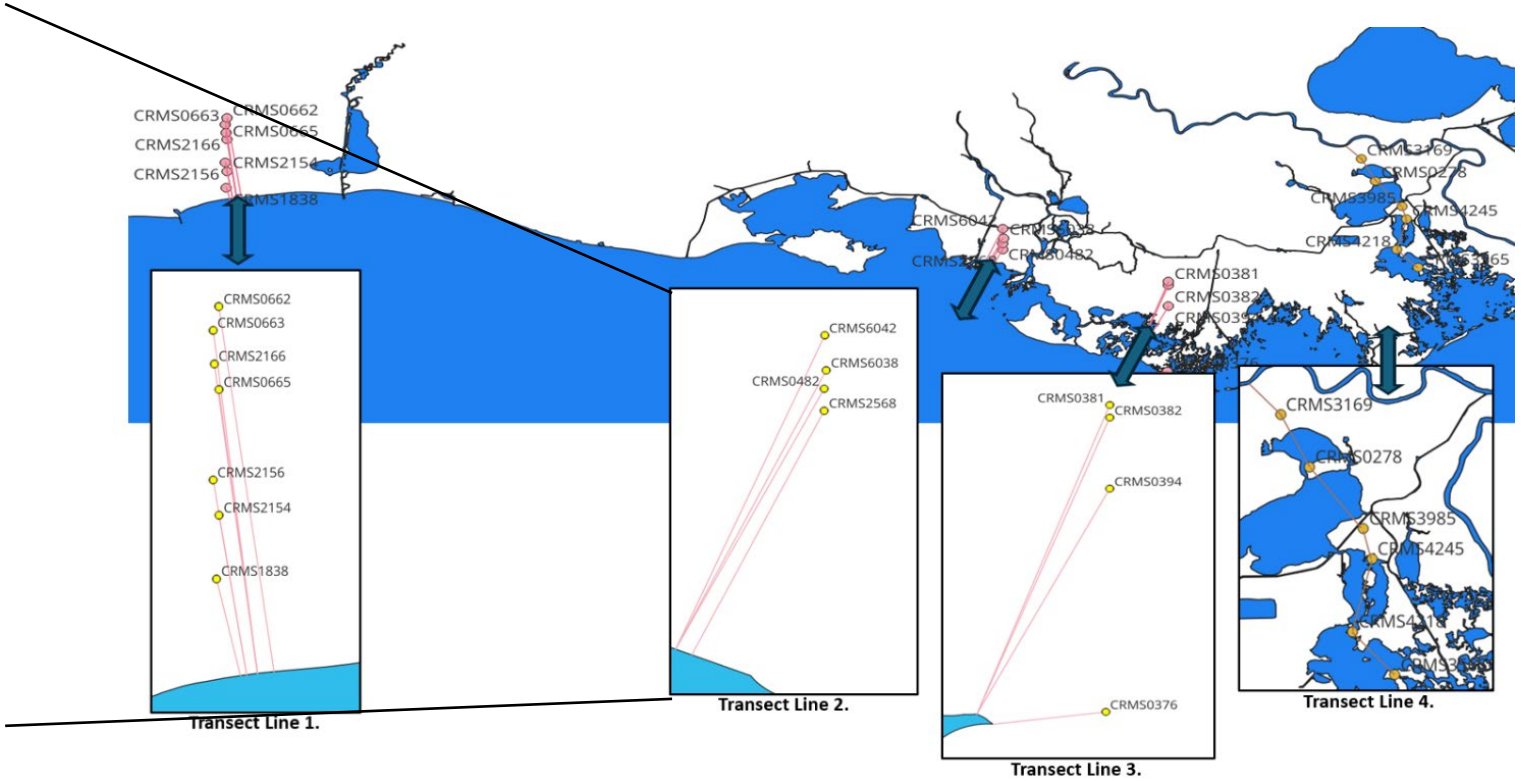

Mean Salinity by Day_CRMS0665
wavelet power levels
Mean Salinity (ppt)
0
10
20
30
40
2010
2015
2020
Time Period (Days)
Hurricane Isaac
Tropical Storm Ida
Drought

Monitoring Resilience in Coastal Wetlands – Transect 1

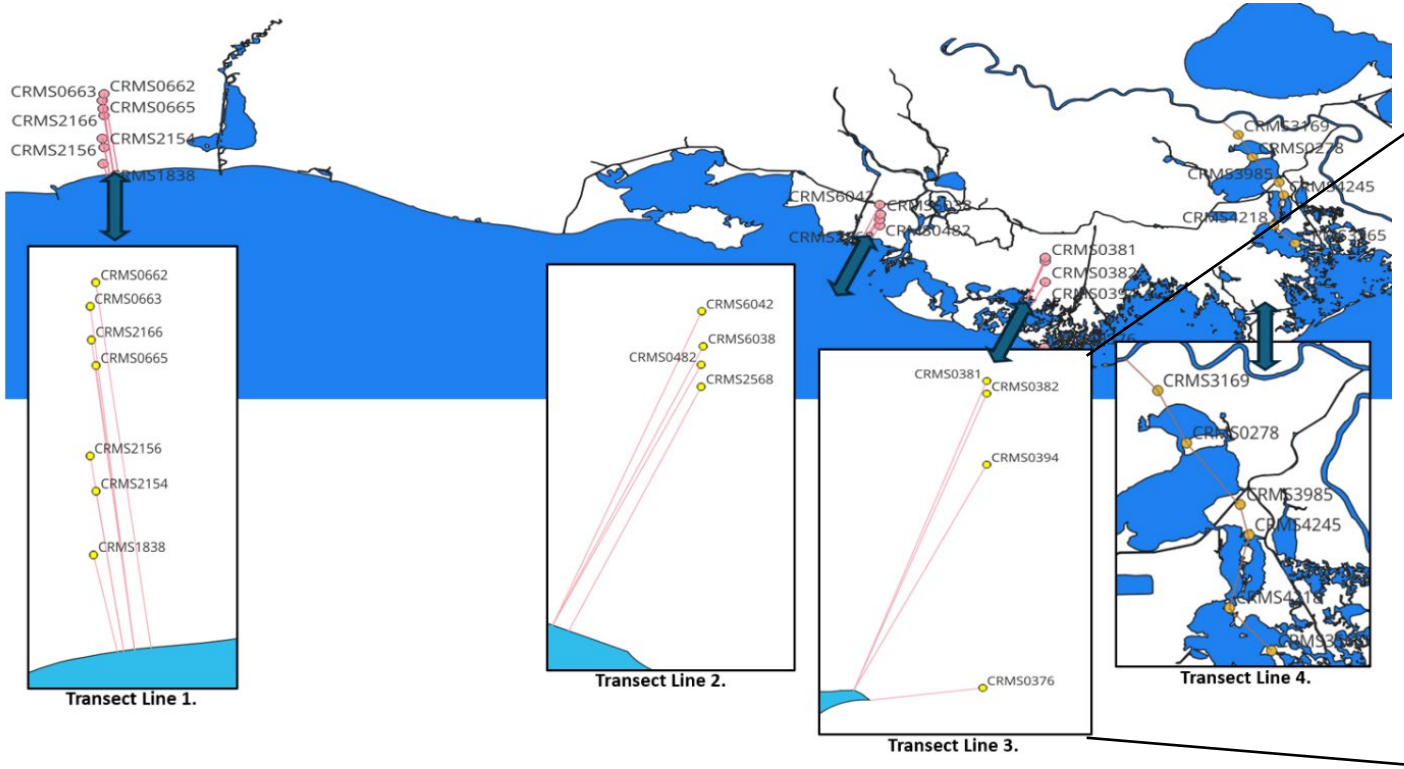


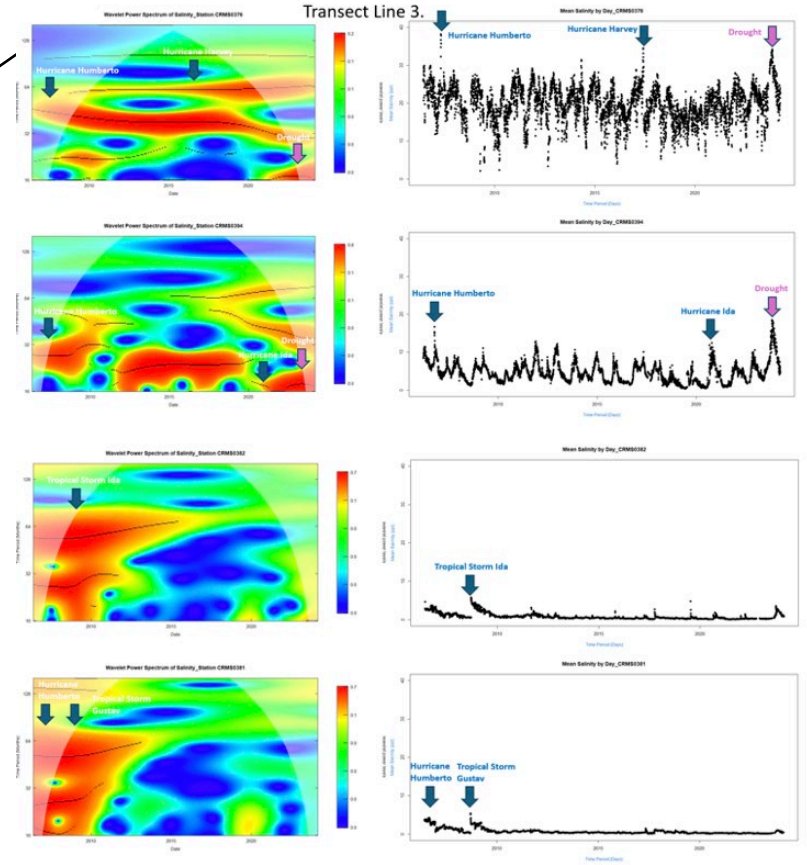
Monitoring Resilience in Coastal Wetlands – Transect 2



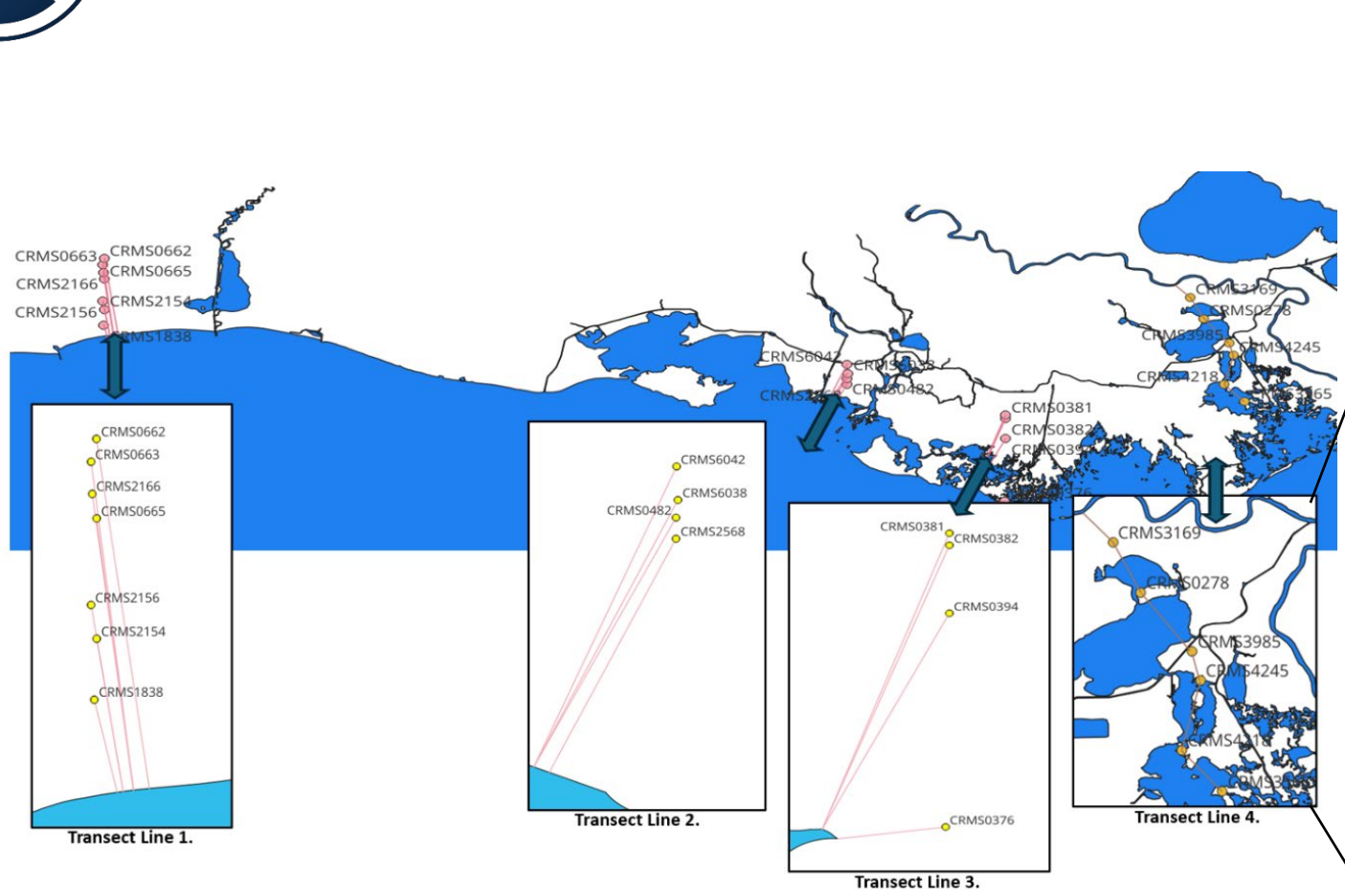


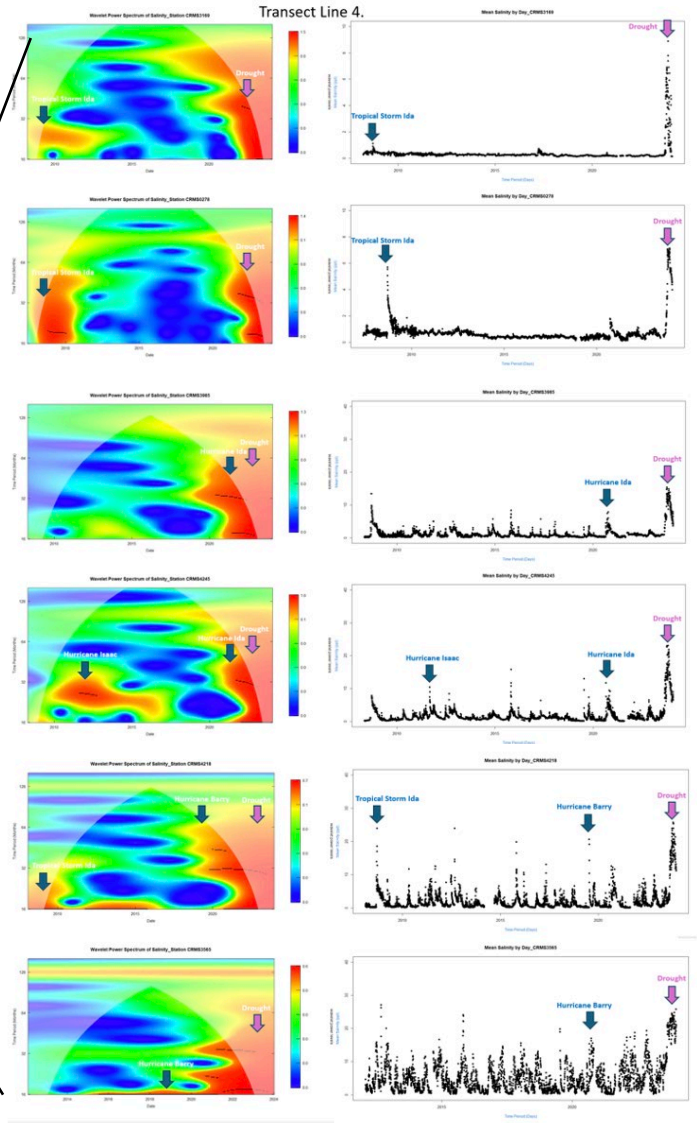
Monitoring Resilience in Coastal Wetlands – Transect 3



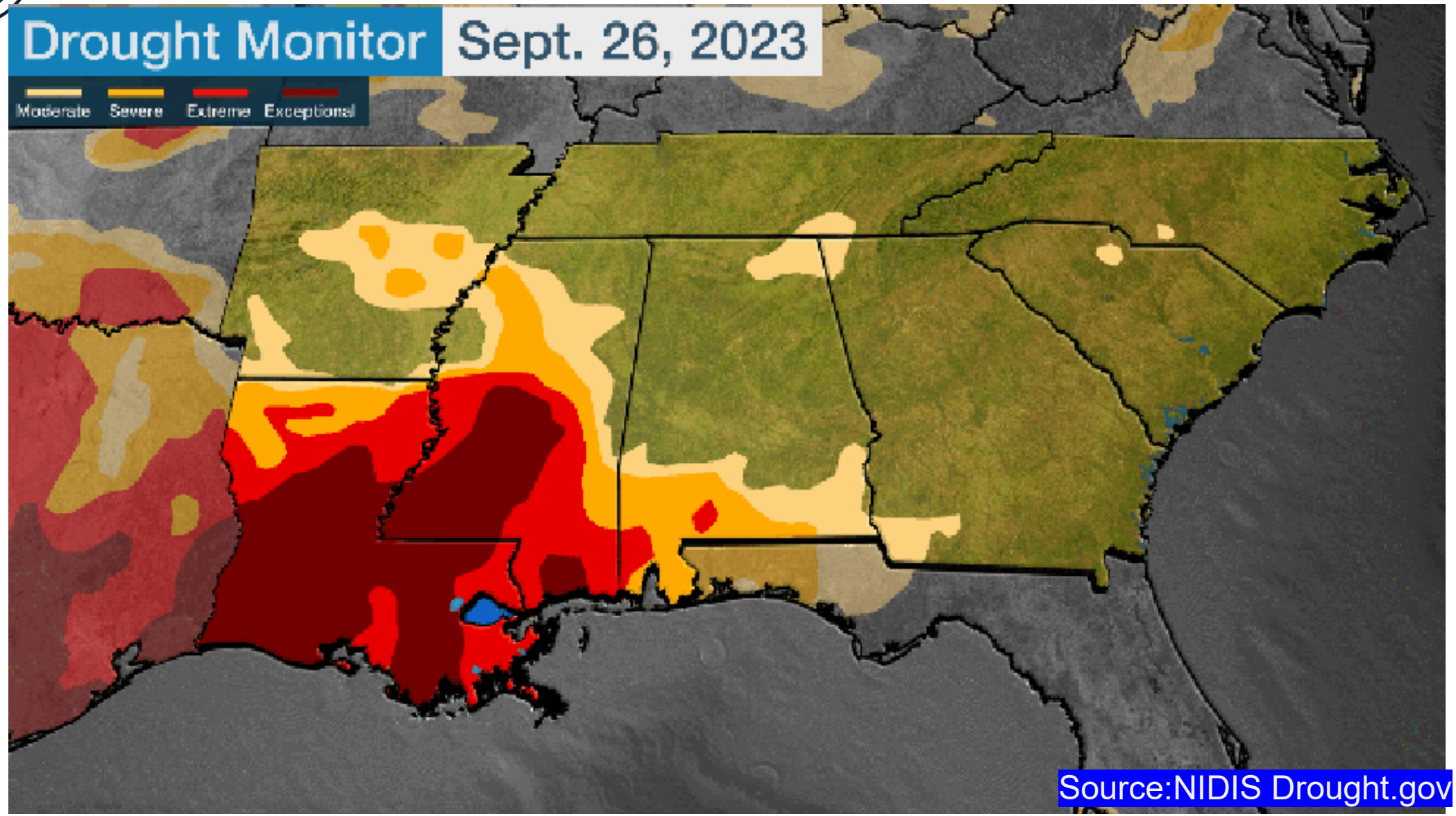


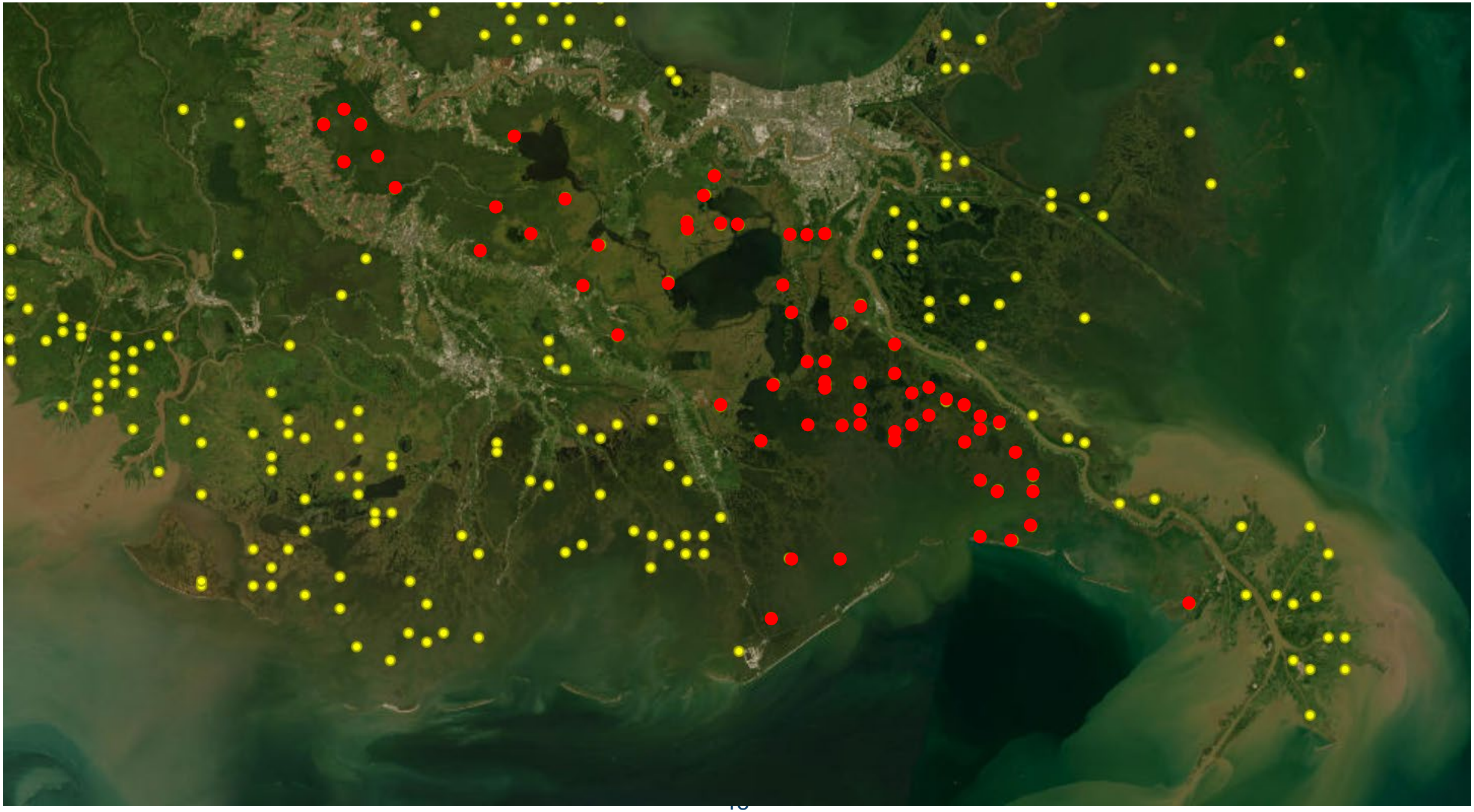
Monitoring Resilience in Coastal Wetlands – Transect 4





Highest, most widespread Drought Levels in 23 years

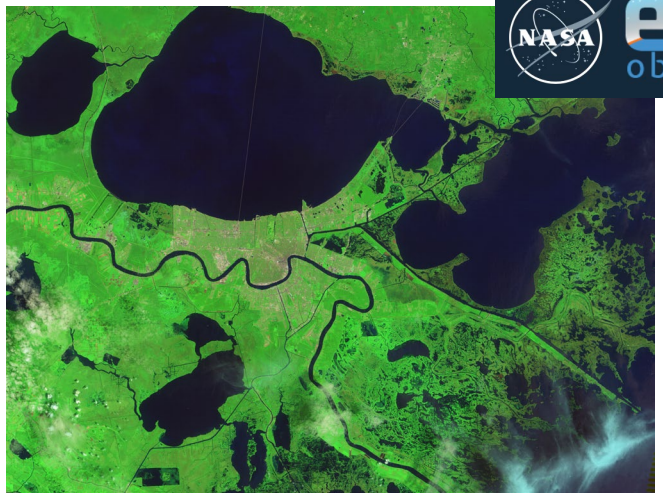




Using large scale, long term monitoring systems to determine resilience in coastal wetland ecosystems

Conclusions

- There is value in large spatial long term monitoring systems, even if the number of parameters being measured is restricted
- We were able to determine the impact of disturbances, such as tropical storms and droughts on the wetland systems and we were to ascertain, to a degree the level of resilience these systems had to perturbations.



One Week Before Katrina - August 22, 2005

Ten Years After Katrina - August 2, 2015

Marsh Browning in the Barataria and Terrebonne Basins

Thank you very much!

Cranfield Environment Centre