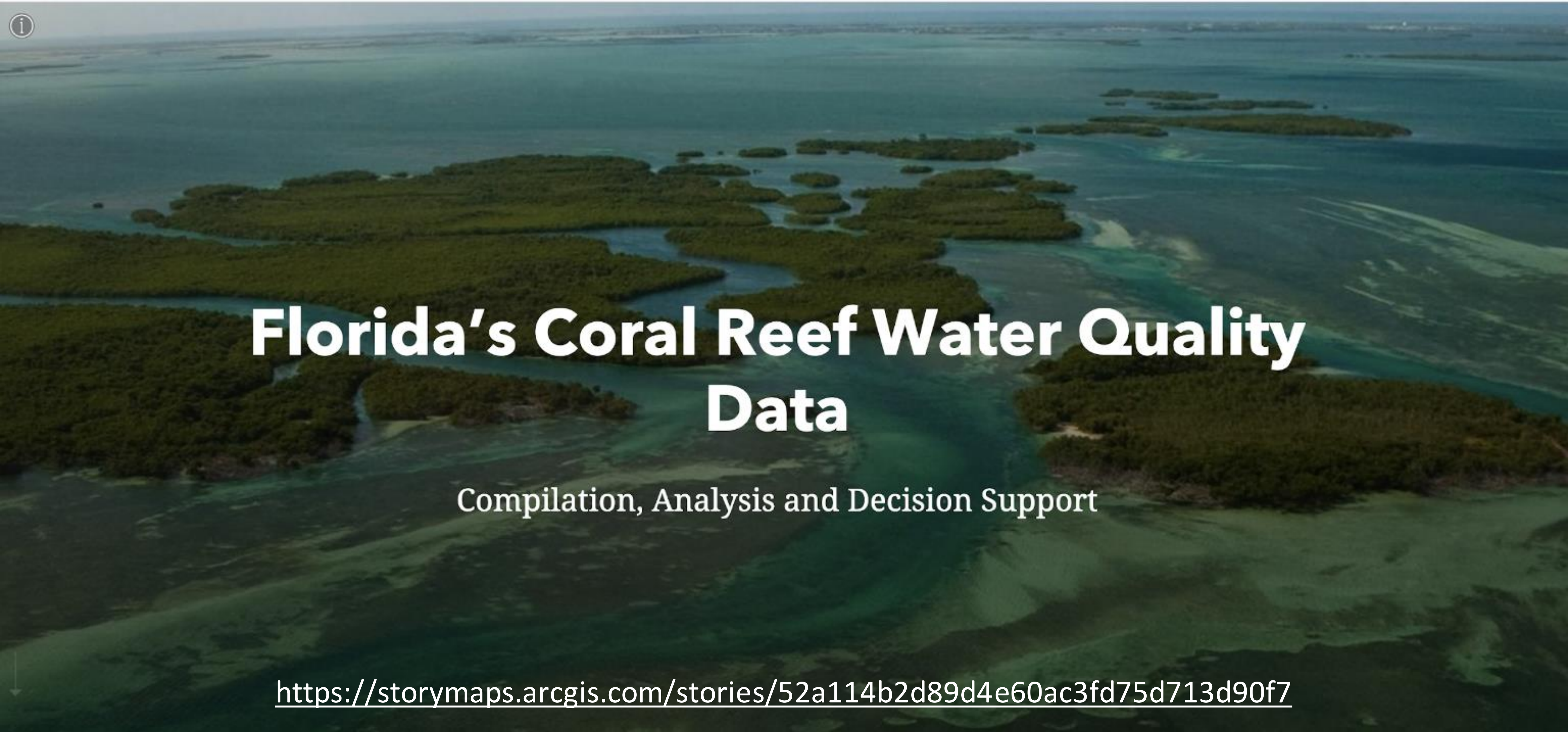

Florida's Coral Reef Water Quality Data

Compilation, Analysis and Decision Support

https://storymaps.arcgis.com/stories/52a114b2d89d4e60ac3fd75d713d90f7

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Project Goals (January 11-June 4)

1. Compile, collate, and map water quality data for the south Florida coral reef ecosystem

1. Construct a matrix to compare water quality sampling programs' parameters and protocols across

1. Analyze the suite of water quality data to identify spatial hotspots and patterns of change

1. Integrate remote sensing of water quality with the field water quality measurements

Water Quality Programs Analyzed/Utilized

- Identified over 80 potential water quality monitoring programs.
- Filtered out programs with insufficient sampling (10 years FKNMS and 5 years minimum outside FKNMS); substantially beyond the geographic extent of the area of interest (the Florida Reef Tract from Monroe to Martin County); and that did not sample most of the parameters of interest
  - Chlorophyll-a, Nitrate+Nitrite (NOx), Soluble Reactive Phosphorus (PO4), Silica (Si), Turbidity, Total Nitrogen (TN), and Total Phosphorus (TP).
- Ultimately, we identified four compatible programs:
  - the South Florida Ecosystem Restoration Cruises (Walton Smith),
  - the Southeast Environmental Research Center Water Quality Monitoring Network (SERC),
  - the Miami-Dade County Department of Environmental Resources Management Water Quality Monitoring Program (DERM), and
  - the Broward County Water Quality Monitoring Program.

Comparison Matrix

Used in Data Analysis?	Dataset	Institution(s)	Contact Person	URL for project	Spatial Distribution	Temporal Frequency	Length of Time Series	Instruments Used	Parameters Analyzed
YES	South Florida Ecosystem Restoration Cruises (Walton Smith)	NOAA AOML, University of Miami CIMAS	Alexandra Fine, alexandra.fine@noaa.gov	https://www.aoml.noaa.gov/ocd/ocdweb/wsmith/wsmith_introduction.html	Key Biscayne to Dry Tortugas, W. FL Shelf and FL Bay	Bimonthly	1998 to Present	SEAL AA3 Autoanalyzer, Turner TD-700 Fluorometer, Shimadzu	SSS, SST, NH4, NOX, NO2, NO3, PO4, Si, Chl-a, TDN, TDP
YES	SERC South Florida Estuaries Water Quality	Florida International University (FIU)	Henry O. Briceño, bricenoh@fiu.edu	http://serc.fiu.edu/wqmnetwork/SFWMD-CD/Pages/DataDL.htm	Northern North Bay to Dry Tortugas, W. FL shelf and FL Bay	Monthly	1988 to Present	Rapid flow analyzer Alpkem model RFA300, Shimadzu, Gilford Fluoro IV Spectrofluorometer, ANTEK 7000N Nitrogen Analyzer	SSS, SST, NOX, NO3, NO2, NH4, TN, DIN, TON, TP, SRP, APA, Chl-a, TOC, SiO2, Turbidity, pH, Kd
YES	DERM	Miami Dade County's Department of Environmental Resources Management (DERM)	Omar Abdelrahman, Omar.Abdelrahman@miamidade.gov, Yin Chen (lab manager) Yin.Chen@miamidade.gov	https://www.miamidade.gov/environment/surface-water-quality.asp	Biscayne Bay	Monthly	2005 to Present	nalytical AA3 Autoanalyzer, Lachat Q	Chl-a, TPO4, TKN, Entero, Ecoli, TP, NH3, NOX, Turbidity
YES	Broward County Water Quality Monitoring Program	Broward County Environmental Lab	Patricia Holowecky, pholowecky@broward.org	https://www.broward.org/NaturalResources/Lab/AboutUs/Pages/canalwaterqualitya.spx	Broward County	Quarterly	2006 to Present	SEAL Analytical AA500, SEAL Analytical AA3 Autoanalyzer	NOX, NH4, TN, TP, Chl-a, TKN, TON, DO, pH, SPC, Salinity, Copper, Entero bacteria

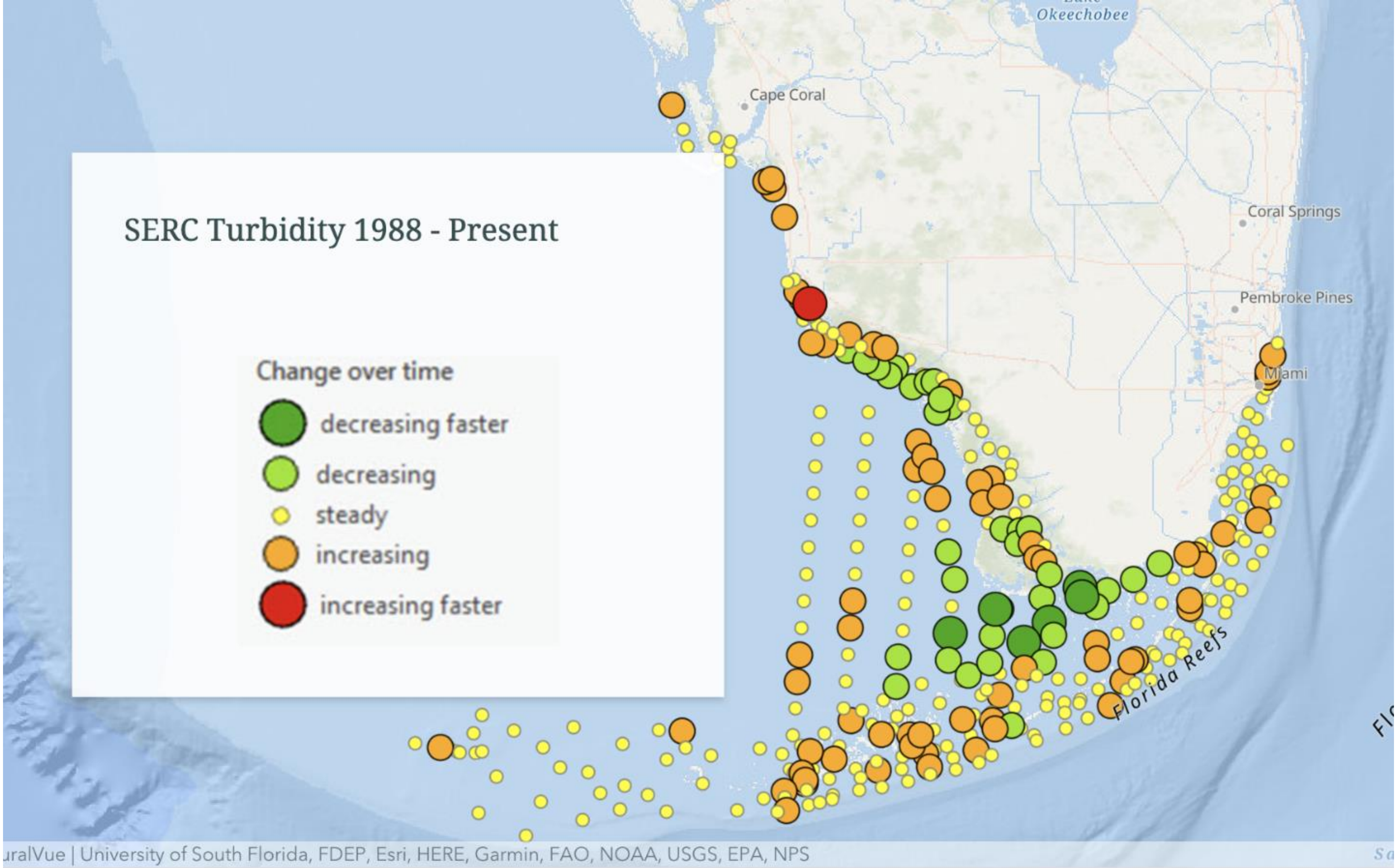
Dataset	Chl-a	NOX	NH4	Si	TDN	TDP	TN	TP	PO4	DIN	TON	TKN	APA	pH	Kd	DO	Turbidity	Entero/ Ecoli	EDCs	NELAC Certified
South Florida Ecosystem Restoration Cruises (Walton Smith)	Shoaf and Lium, 1976	Zhang 2000	Zhang et al. 1997	Zhang and Berberian, 2000	X	X			Zhang et al. 2000							[illegible] Handheld				NO*
SERC South Florida Estuaries Water Quality	Strickland and Parsons, 1972	Alpkem Corporation, 1986	Alpkem Corporation, 1989	X			Frankovich and Jones, 1998	X	Alpkem Corporation, 1987	X	X		X	X	X		HF Scientific model DRT-15C turbidimeter			YES
DERM	EPA 445.0	EPA 353.2	EPA 350.1				EPA 351.4	EPA 365.1	EPA 365.1			EPA 351.2						X		YES*
Broward County Water Quality Monitoring Program	EPA 445.0	EPA 353.2	EPA 350.1				EPA 353.2 + EPA 351.2	EPA 365.4			EPA 351.2 - EPA 350.1	EPA 351.2		YSI ProDSS		YSI ProDSS	X	X*		YES

Dataset	Methodologies Used
South Florida Ecosystem Restoration Cruises (Walton Smith)	Samples are collected using CTD. Nutrient samp filtered at sea using 0.45 micron nylon syringe filt and stored in freezer until analysis. Nutrient analy for NO2, NO3, NOX, PO4, Si and NH4 on SEAL AA Nutrient Autoanalyzer following various Zhang methods. Chlorophyll-a samples are filtered thro
SERC South Florida Estuaries Water Quality	Duplicate, unfiltered water samples are collected and kep ambient temperature in the dark during transport. Samp are filtered by hand through 25mm GF/F glass fiber filte sample rinsed 60 ml HDPE bottles, which were capped a immediately placed on ice in the dark for transport. The filters, used for chlorophyll a analysis were placed in 1.8 plastic centrifuge tubes to which 1.5 ml of 90% acetone
DERM	Orthophosphate: Collect orthophosphate unfilte and unpreserved. Holding time is 48 hours per E 365.1. They do not heat the molybdate - reactio occurs at room temperature to reduce interferen with Si, which they don't currently measure. Nutrie collected in a separate bottle, pre-washed wit
Broward County Water Quality Monitoring Program	Gas chromatography and mass spectrometry absorption and emission spectroscopy, all follow EPA and FDEP regulations. All samples are proces unfrozen. NOX, NH4, TKN and TP samples are acidified to pH <2 with sulfuric acid. Orthophosph samples are unacidified and filtered within 15 minu Hold time is 48 hours for unacidified samples and days for acidified samples.

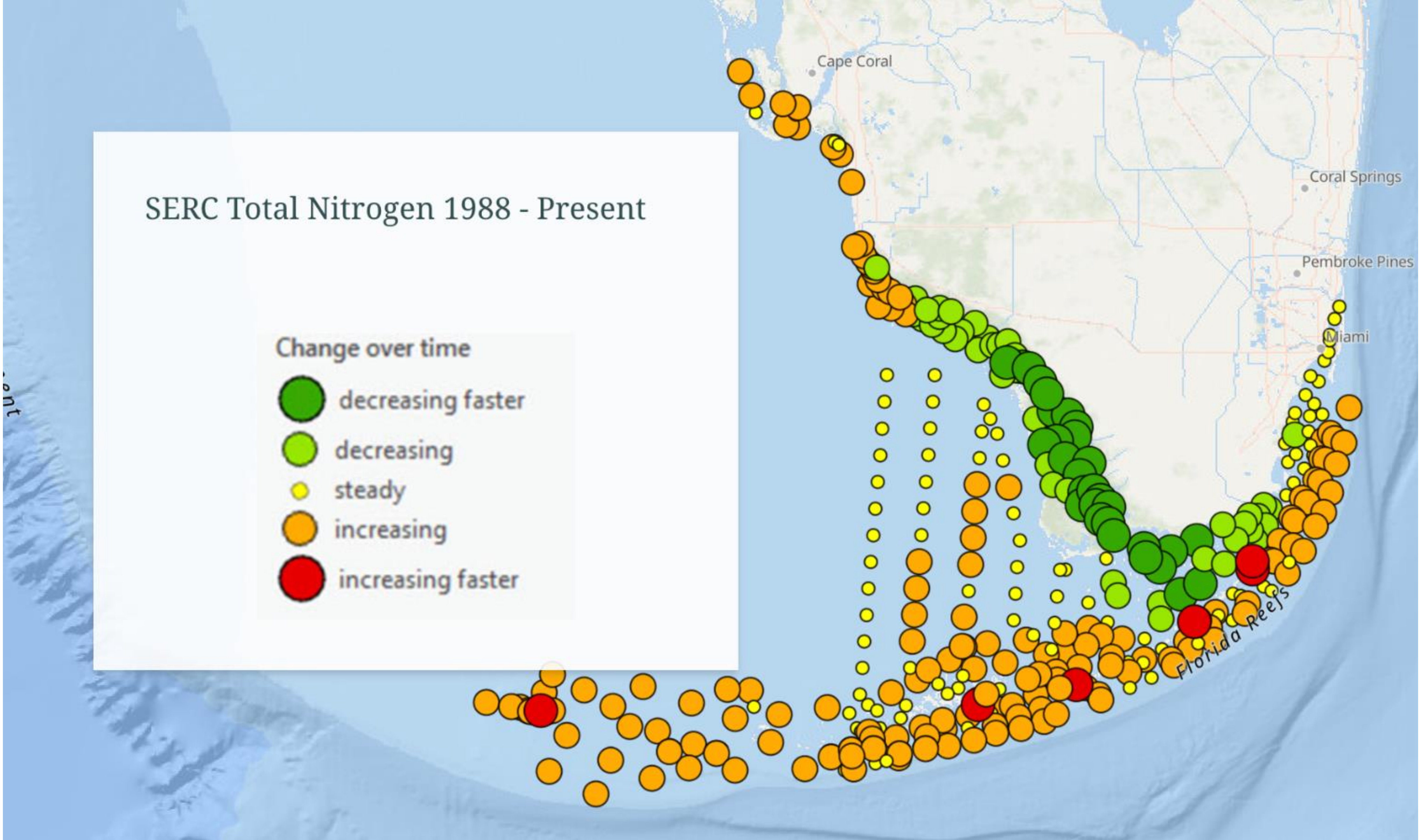
Dataset, Institution, POC, website, spatial coverage, temporal coverage and frequency, Instruments Used, Parameters Analyzed, Methodologies (Chl a, NOx, NH4, TDP, TDN, TN, TP, PO4, DIN, TON, APA, pH, Kd, DO, Turbidity, E. coli, EDCs), NELAC certification

Hot-spot analysis

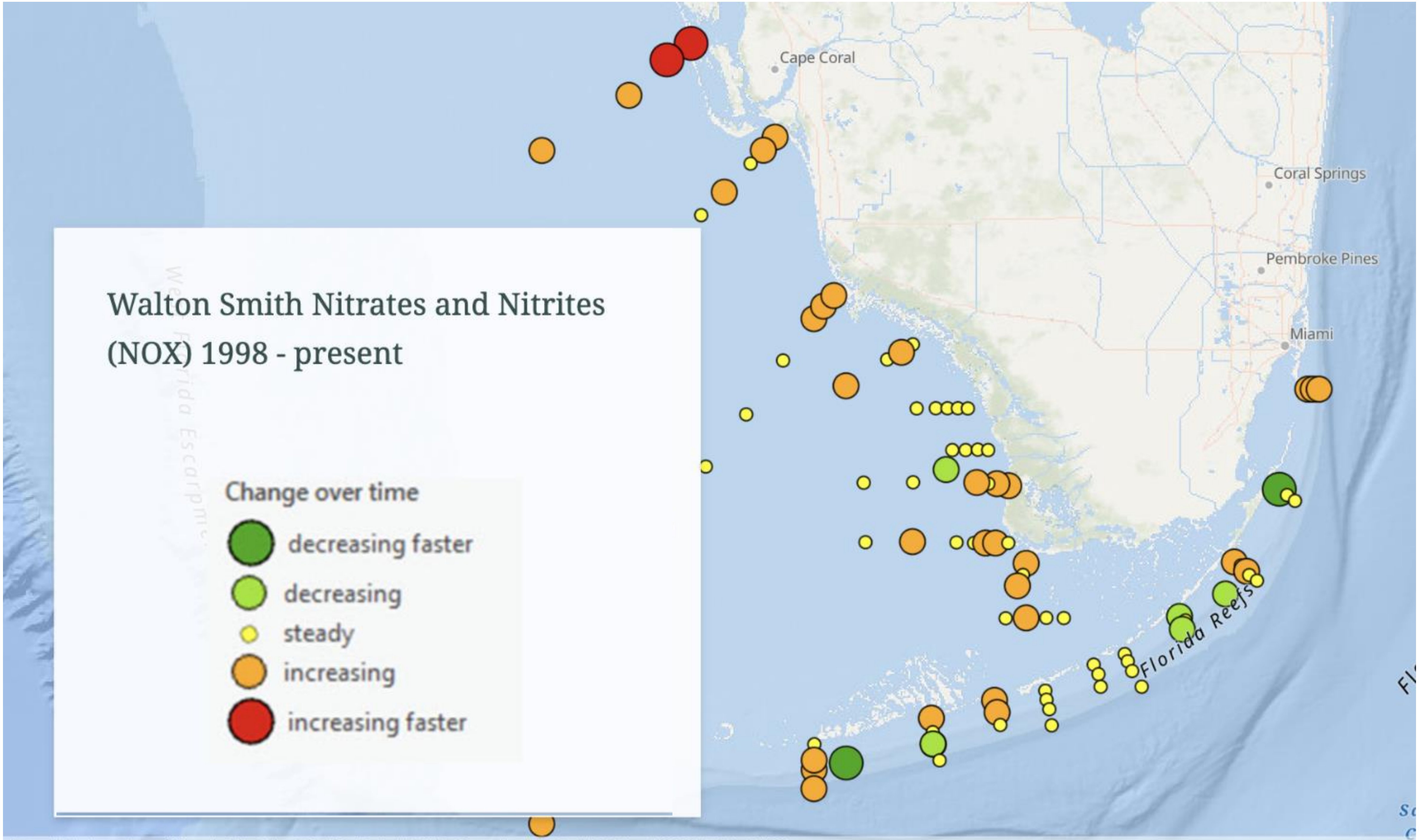
- Analyzed Thiel-Senn slope of Seasonal Mann-Kendall (Millette et al. 2019)
- Analyzed by parameter (turbidity, total nitrogen, NOX, silicate, phosphorous, and chlorophyll-a)
- Did not analyze slopes across monitoring programs (yet)
- Same method is applied to identify hot-spots via remote sensing


SERC Turbidity 1988 - Present
Change over time
decreasing faster
decreasing
steady
increasing
increasing faster
Okeechobee
Cape Coral
Coral Springs
Pembroke Pines
Miami
Florida Reefs
uralVue | University of South Florida, FDEP, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS

SERC Total Nitrogen 1988 - Present



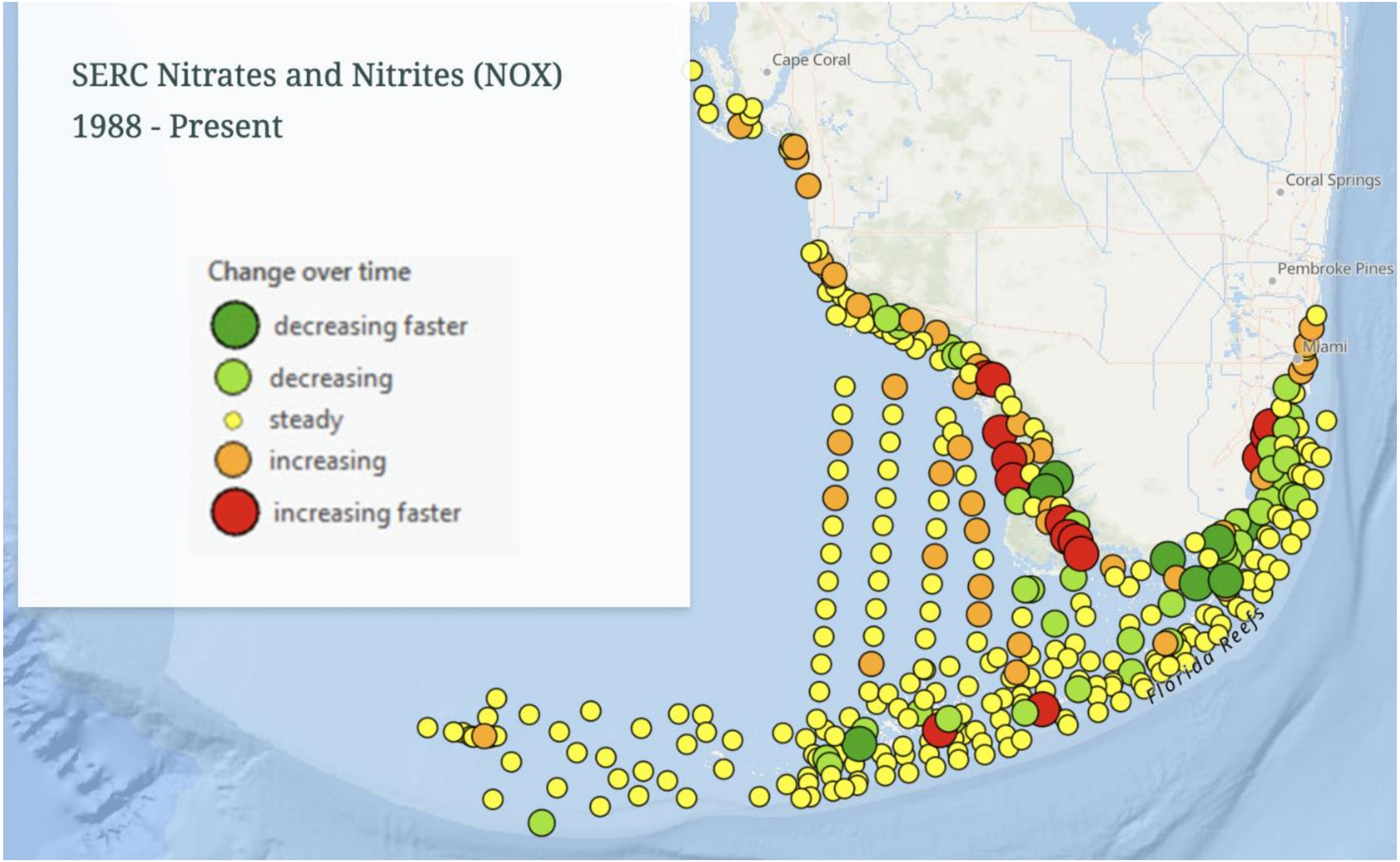
Walton Smith Nitrates and Nitrites (NOX) 1998 - present

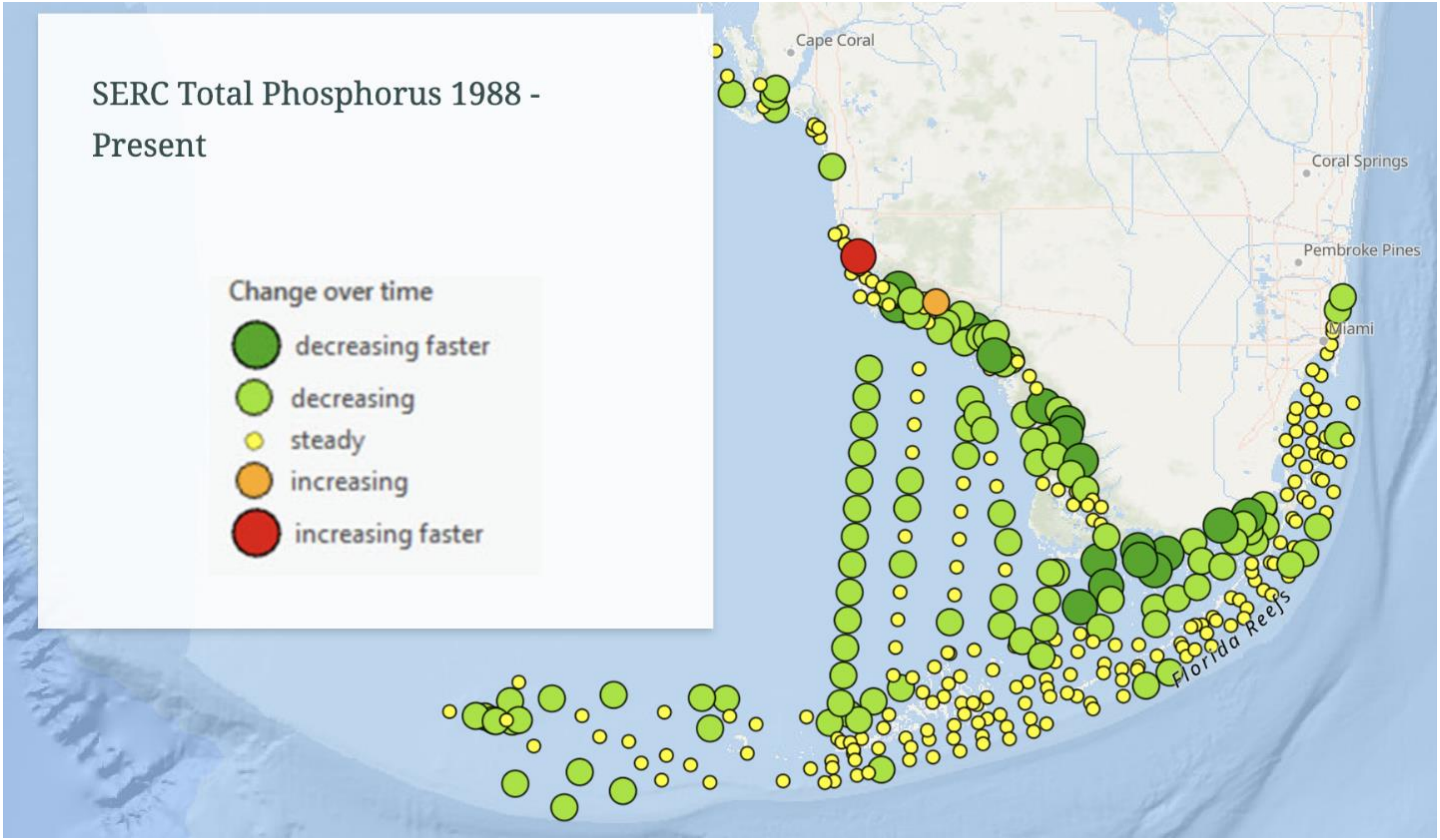


alVue | University of South Florida, FDEP, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS

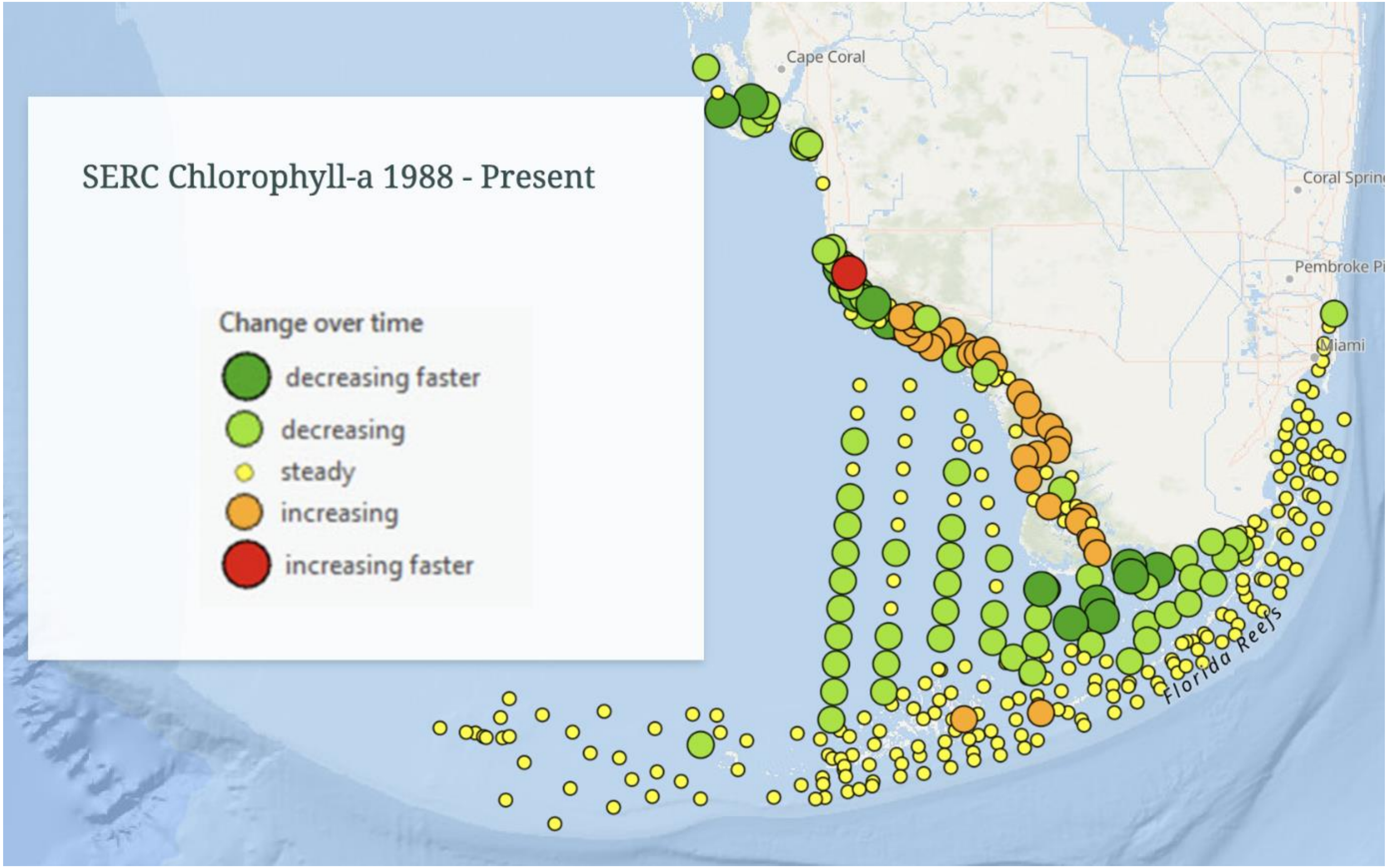
SERC Nitrates and Nitrites (NOX)

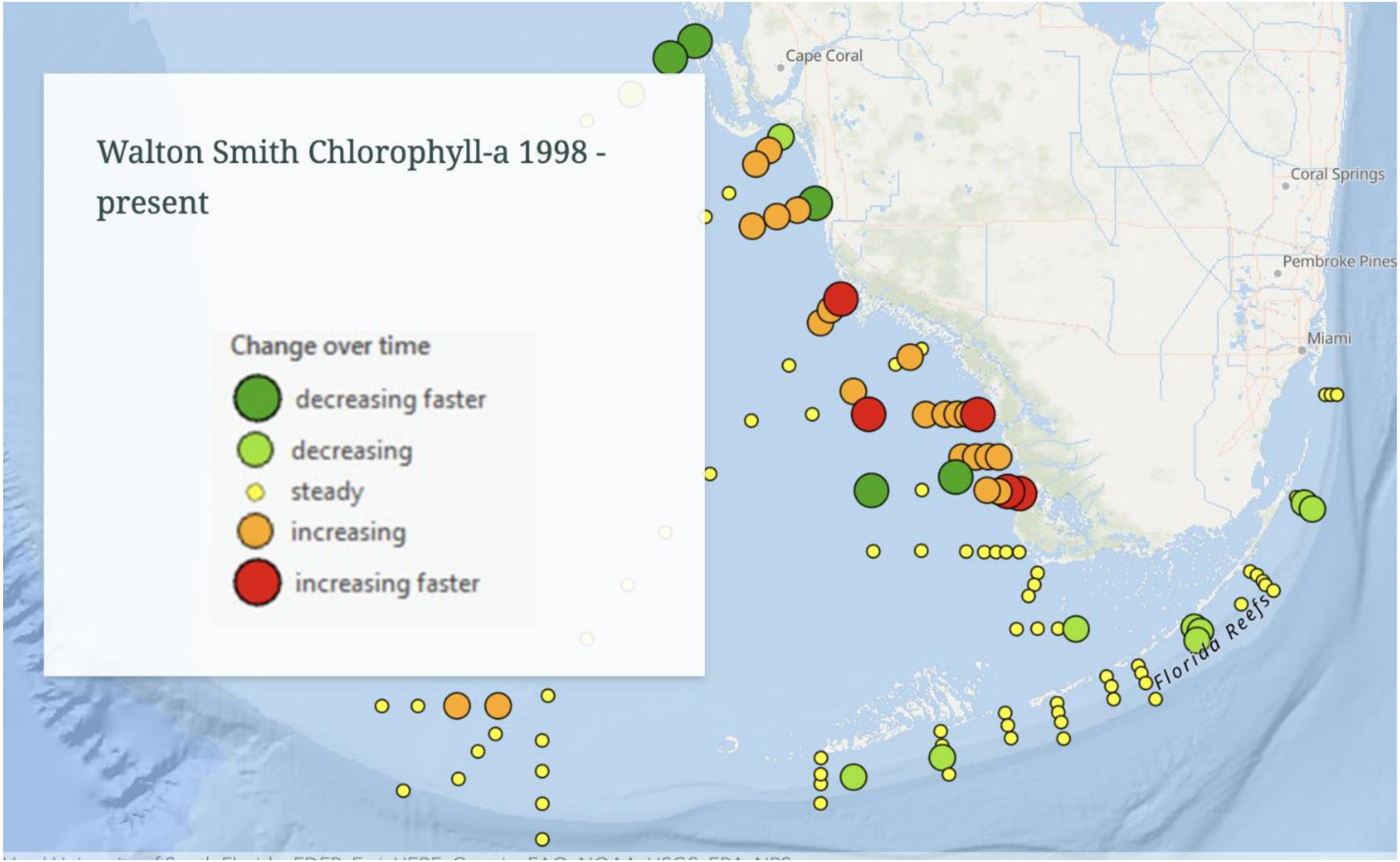
1988 - Present

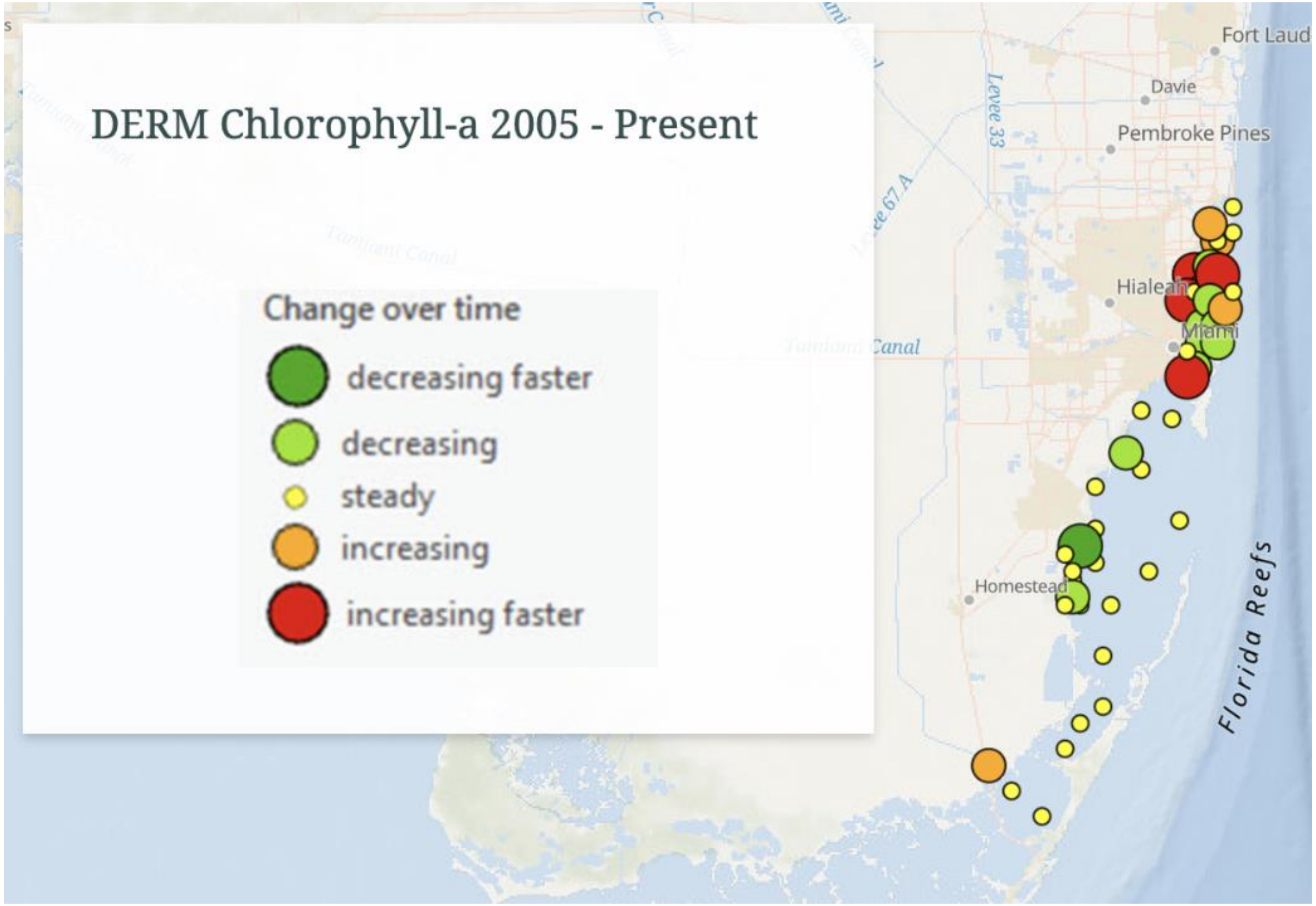



SERC Total Phosphorus 1988 - Present
Change over time
decreasing faster
decreasing
steady
increasing
increasing faster
Cape Coral
Coral Springs
Pembroke Pines
Miami
Florida Reefs

SERC Chlorophyll-a 1988 - Present




Walton Smith Chlorophyll-a 1998 - present
Change over time
decreasing faster
decreasing
steady
increasing
increasing faster
Cape Coral
Coral Springs
Pembroke Pines
Miami
Florida Reefs

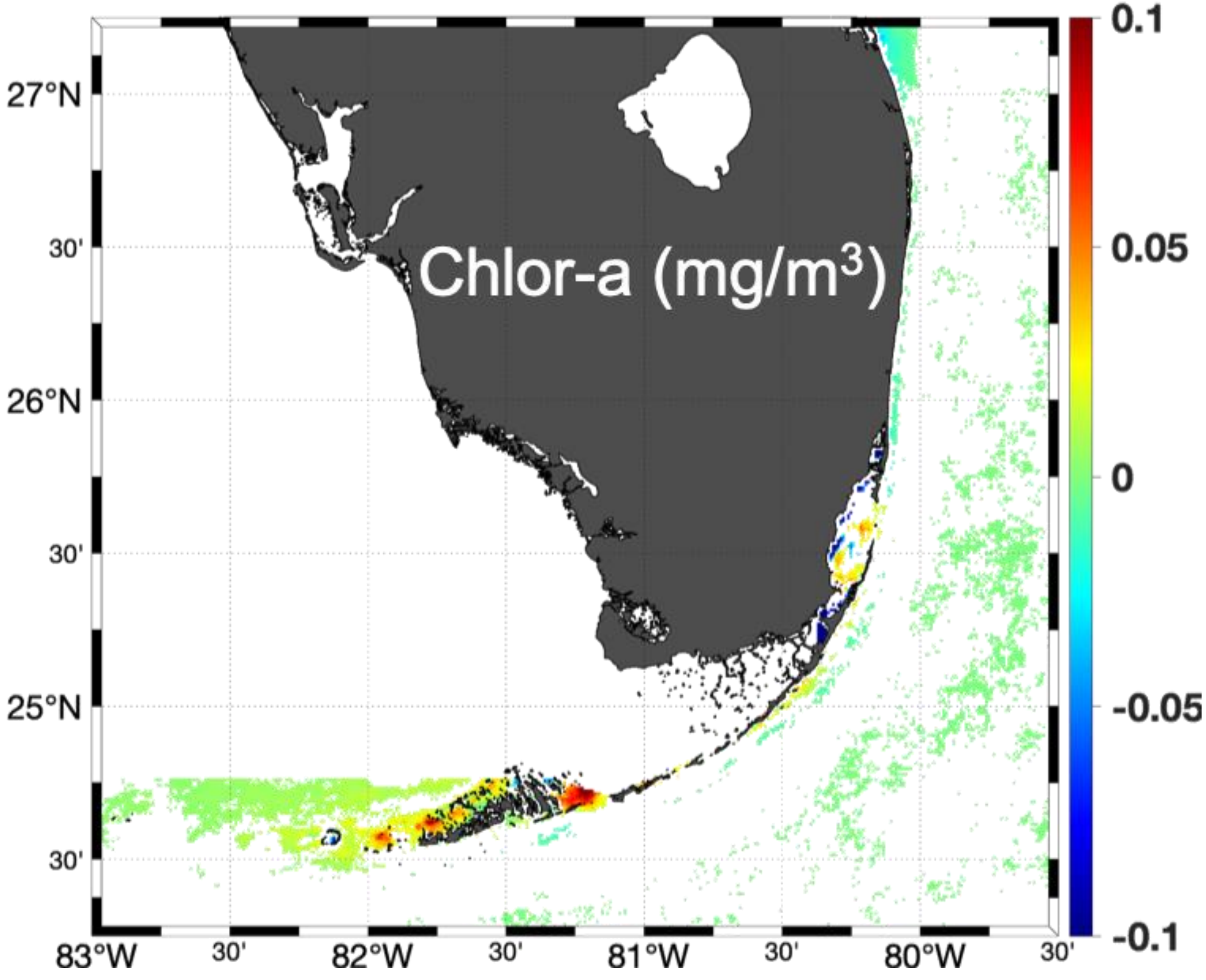

DERM Chlorophyll-a 2005 - Present
Change over time
decreasing faster
decreasing
steady
increasing
increasing faster
Fort Laud
Davie
Pembroke Pines
Hialeah
Miami
Homestead
Florida Reefs
Levee 33
Tamiami Canal

MODIS Aqua satellite (2003-2020)

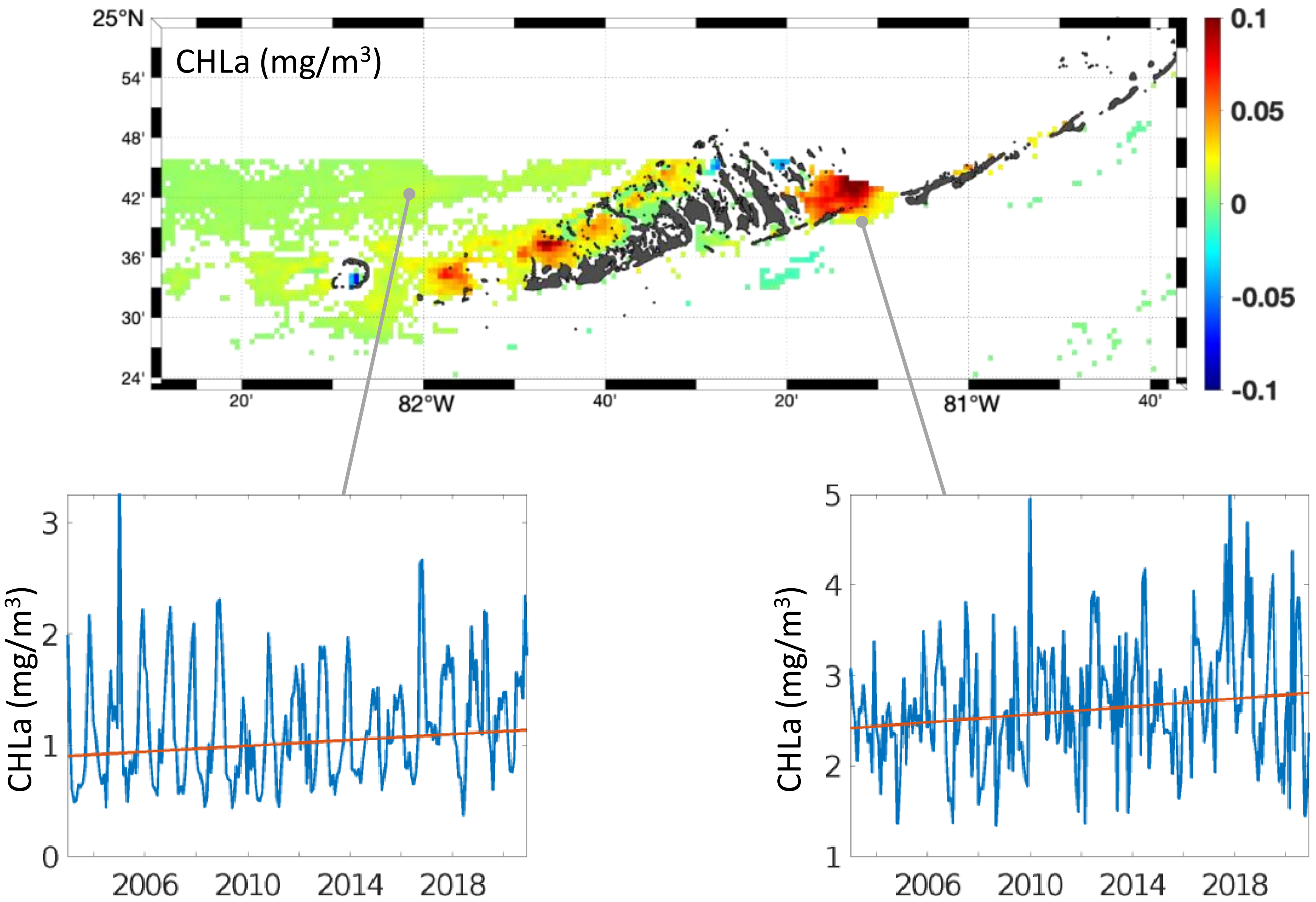
Each 1-km satellite pixel treated as a time series.

Theil-Sen slope used to assess trends in water quality parameters over time.

Only pixels showing significant trends are shown.

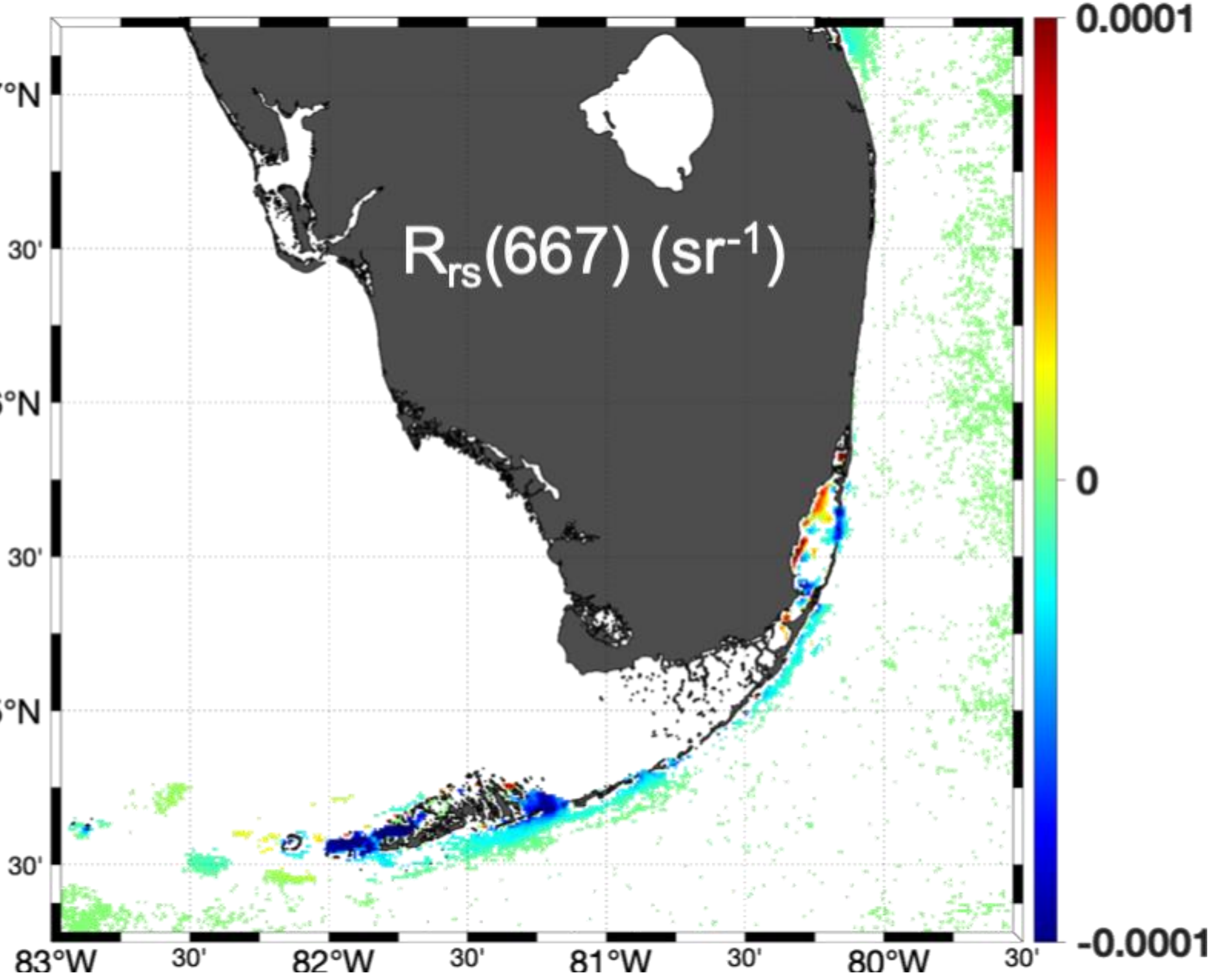


Warm colors – pos. trend
Cold colors – neg. trend

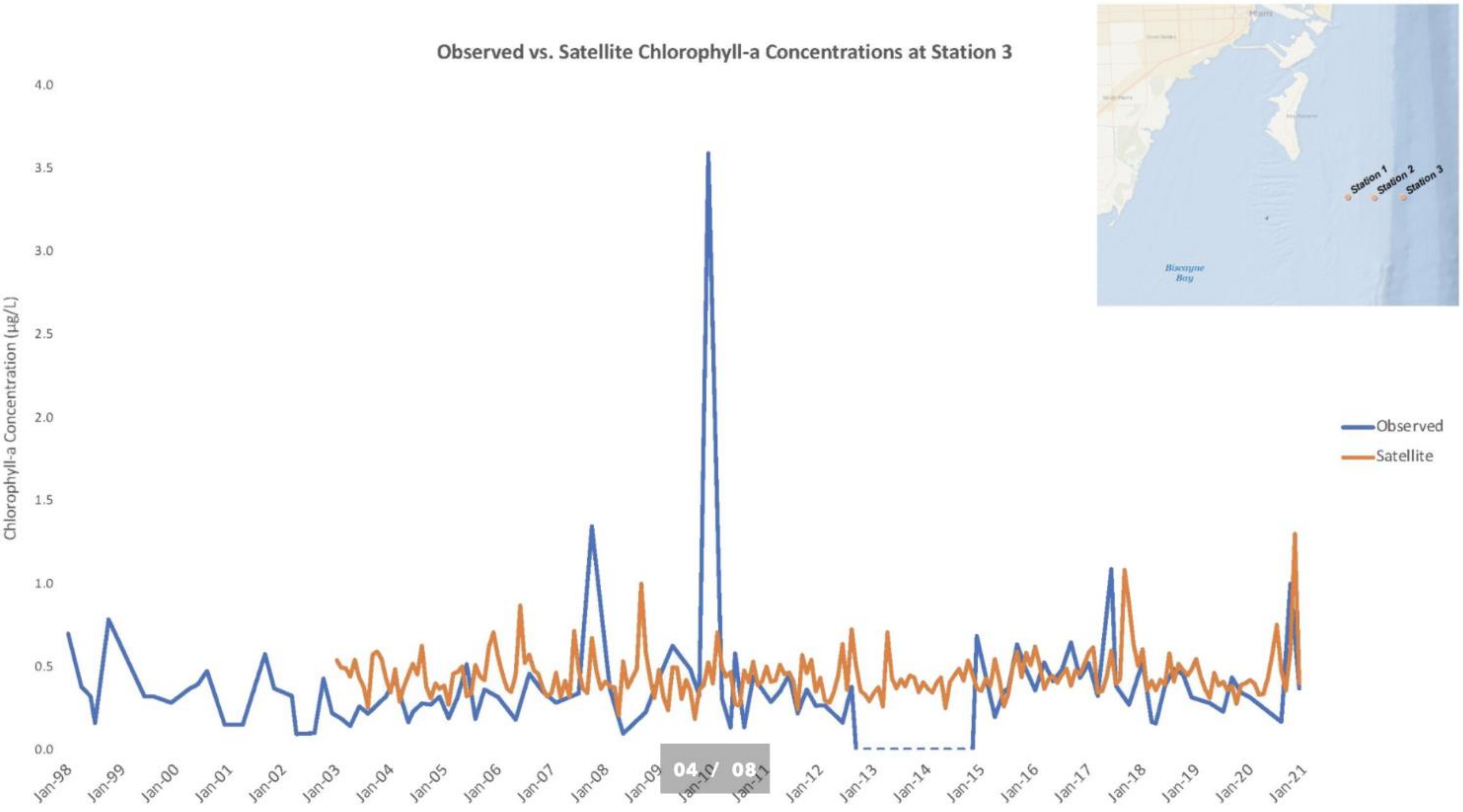


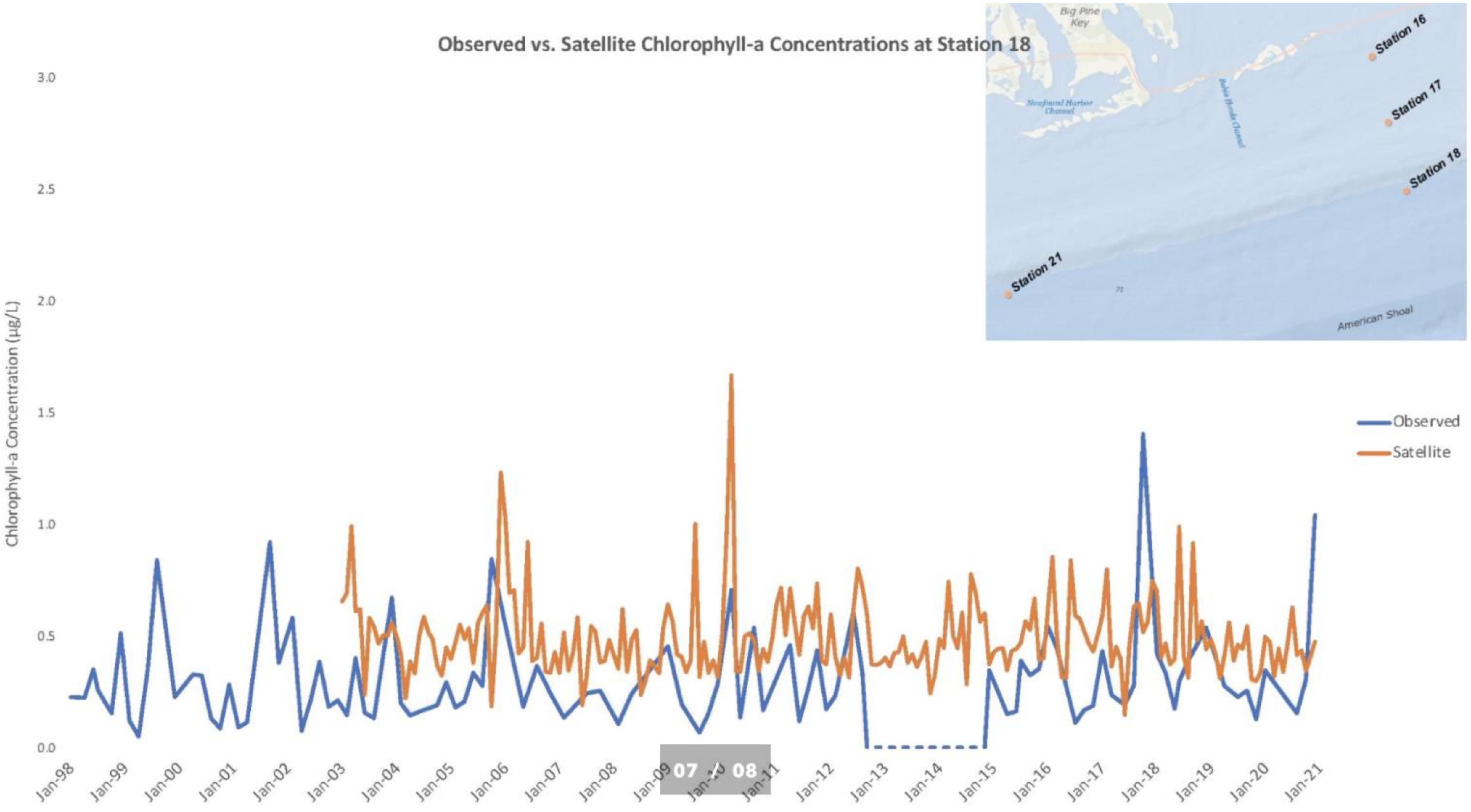
CHLa (mg/m³)
25°N
54'
48'
42'
36'
30'
24'
20'
82°W
40'
20'
81°W
40'
0.1
0.05
0
-0.05
-0.1
CHLa (mg/m³)
3
2
1
0
2006
2010
2014
2018
CHLa (mg/m³)
5
4
3
2
1
2006
2010
2014
2018

Red reflectance is a proxy for suspended sediments.



Warm colors – pos. trend
Cold colors – neg. trend


Observed vs. Satellite Chlorophyll-a Concentrations at Station 3
Chlorophyll-a Concentration (µg/L)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Observed
Satellite
Station 1
Station 2
Station 3
Biscayne Bay


Observed vs. Satellite Chlorophyll-a Concentrations at Station 18
Chlorophyll-a Concentration (µg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Observed
Satellite
Big Pine Key
Newfound Harbor Channel
Bahia Honda Channel
Station 16
Station 17
Station 18
Station 21
American Shoal
07 / 08

Conclusions

- 4 Programs can all be used to determine long-term trends in key water quality parameters
- Trends do not indicate red flags at first glance, but these are preliminary results at the regional scale
- Different time ranges cause different results
- Remote sensing can help to fill gaps
  - matches to observations are best in more offshore sites

Next Steps

- Compare between programs where they overlap in space and time
- Conduct the hotspot analysis on a consistent time-range to answer management questions
  - What are the most relevant time ranges?
- Incorporate more programmatic monitoring programs in the analyses
  - DEP/CRCP program
- Conduct a detailed gap analysis
- Compare water quality and benthic trends
- Make recommendations to improve utility and consistency of monitoring programs

Solutions

1) Databases use different naming conventions for basic information.
Solution: Agree to common naming conventions among existing programs, and/or create code that automatically renames datasets to a common framework moving forward.

2) Station names between, and within, monitoring programs can be inconsistent.
Solution: Use unique names with a reference key and easily accessible metadata.

3) Stations are rarely sampled at the exact same location in repeated visits
Solution: Provide coordinates as the average or define a fixed coordinate for each station.

4) The time frame(s) of interest can differentially weight trends
Solution: Time periods of interest need to be defined by management questions

5) Some programs sample year-round and others only sample in the summer.
Solution: Require quarterly sampling at minimum and more frequent sampling is preferred.