

***Development of a Water  
Clarity Index for the  
Southeastern US as a  
climate indicator***

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## HYPOTHESIS

- Episodic and seasonal weather events are mechanistically linked to changes in southeast coastal water clarity, and changes in the frequency and intensity of these events yield responses in water clarity on multiple timescales

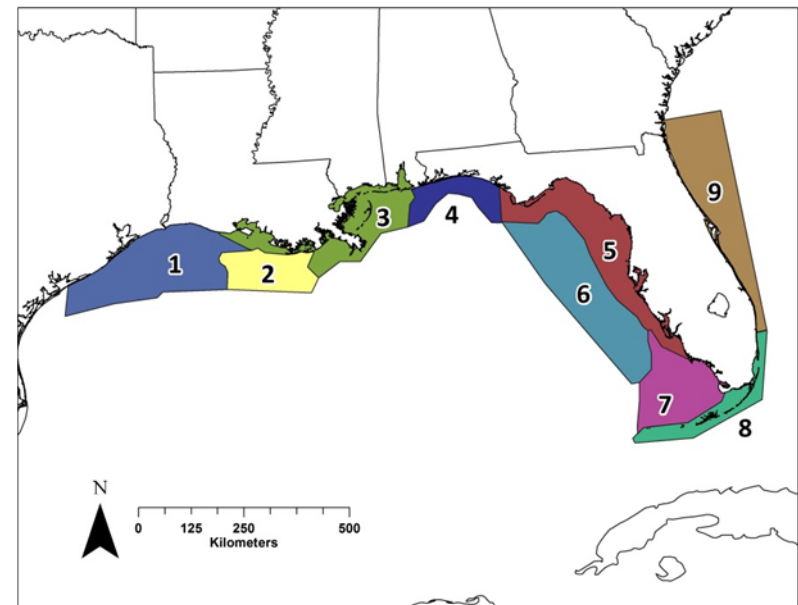
## OBJECTIVES

- Develop a multi-decadal water clarity indicator (*Kd index*) for coastal waters of the southeastern United States
- Assess how events and changes in atmospheric conditions are associated with *Kd index*
- Develop a long-term reconstruction of *Kd Index* to analyze changes, while also serving as a monitoring tool in coastal regions for assessing impacts on light-sensitive species such as corals and seagrass.

# Hypothesis and objectives

- Discontinuous time periods available:
  - 1978-1986
    - CZCS
  - 1997-present
    - SeaWifs (1997-2010)
    - MODIS (2002-)
- Reflectance data sampled to 1km interval within region
- $K_d488$  (turbidity) determined through algorithms
  - Optically shallow water evaluated differently
- *Kd Index* created by normalizing *Kd* data through climatology

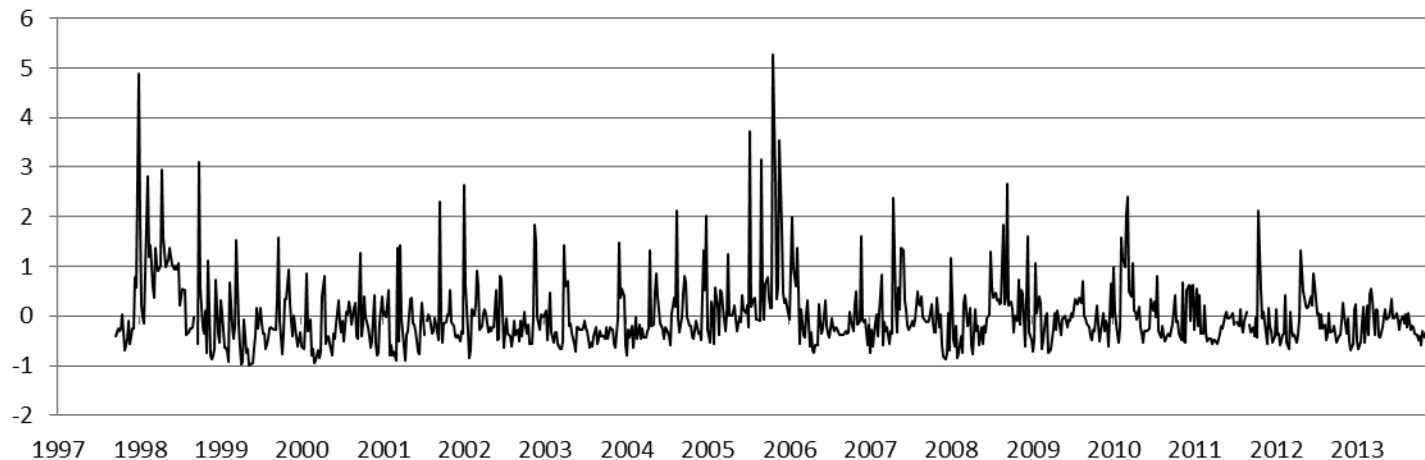
*Kd Index*



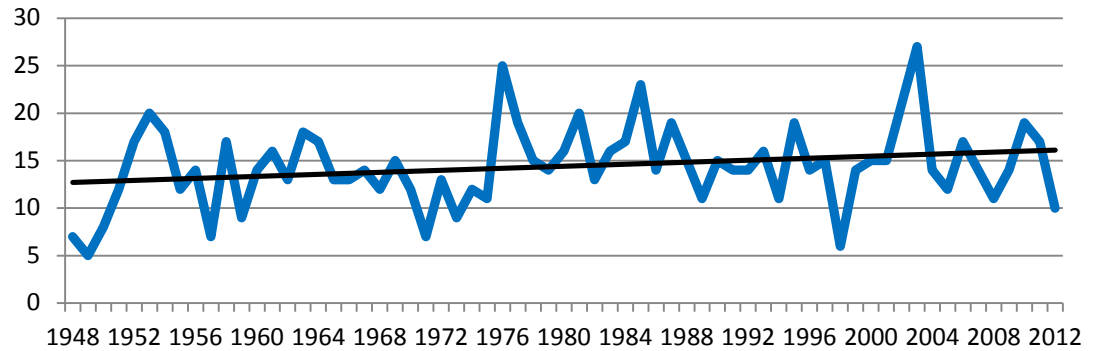
- Regionalization
  - Cluster analysis of *Kd Index* time series
  - 263,590 pixels -> 9 regions
- Temporal and spatial filtering to derive time series that addresses gaps in coverage
  - Weekly and daily data sets produced.

## *Kd Index*

**Region 7 Kd Index**



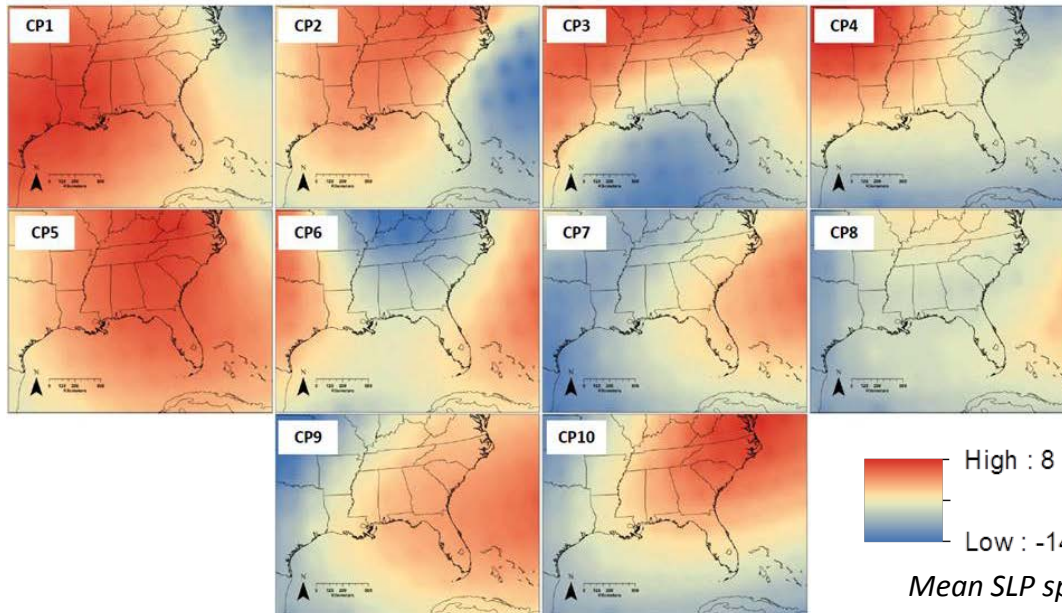
# CP1



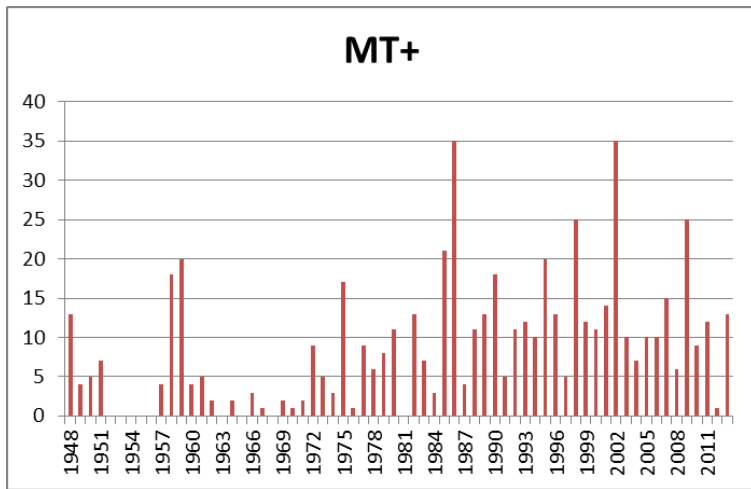
Winter frequencies by year of CP1

- NNR Reanalysis sea level pressure data, 1948-2013
- Cluster analysis of SLP spatial anomalies yields 10 circulation patterns

## Atmospheric circulation data

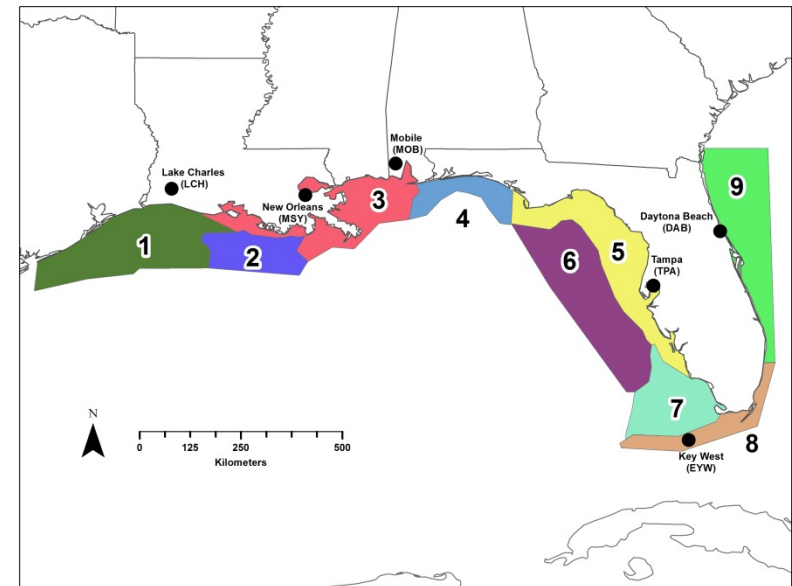


Mean SLP spatial anomaly values by circulation pattern



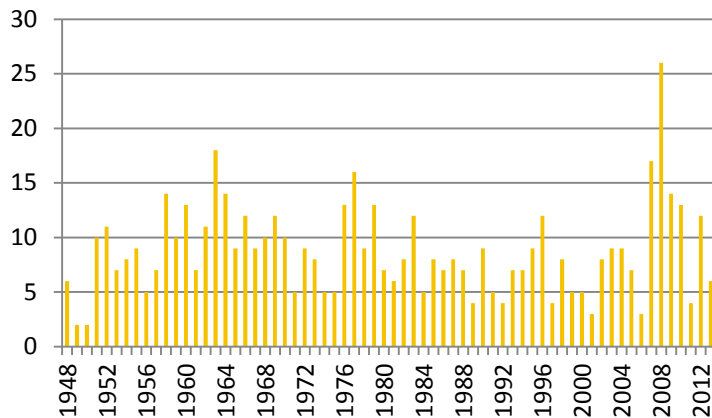
*Frequency of MT+ days, Tampa, autumn*

- Spatial Synoptic Classification (SSC) data obtained for coastal stations adjacent to the regions.



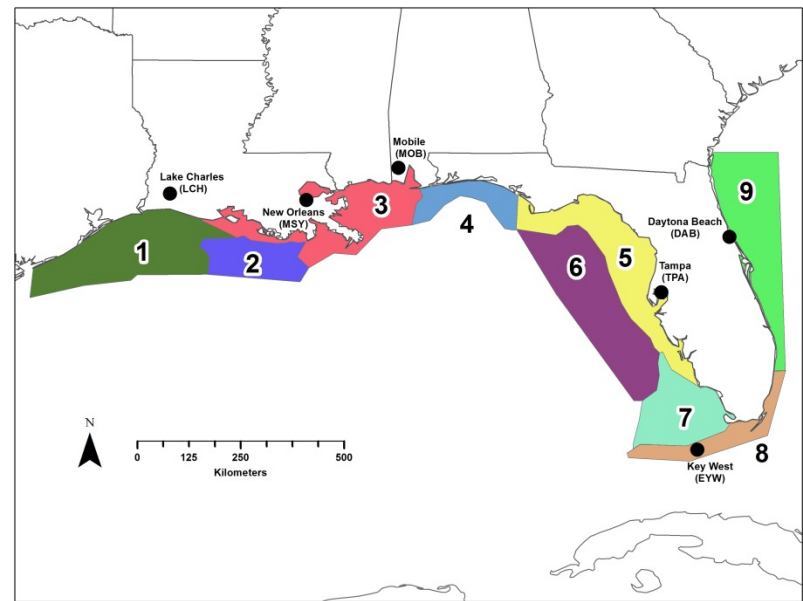
## Surface weather type data

### TR



*Frequency of TR days, Tampa, winter*

Abb.	Type
DM	Dry Moderate
DP	Dry Polar
DT	Dry Tropical
MM	Moist Moderate
MP	Moist Polar
MT(+, ++)	Moist Tropical (Plus, Plus-Plus)
TR	Transitional



## Heavy precipitation data

- Mean regional precipitation by day estimated from NARR reanalysis across each of the 9 regions
- Station precipitation data by day for adjacent coastal stations

- Modeling the *Kd index* – climate relationship
  - Correlation analysis to determine most critical determinants of *Kd index* variability
  - Multivariate linear mixed model, distributed lags
  - Binary logistic regression model, distributed lags
- Development and validation
  - Tested on 1997-present
  - Cross-validated and validated against earlier data
  - Development of historical *Kd index* values based on developed relationships

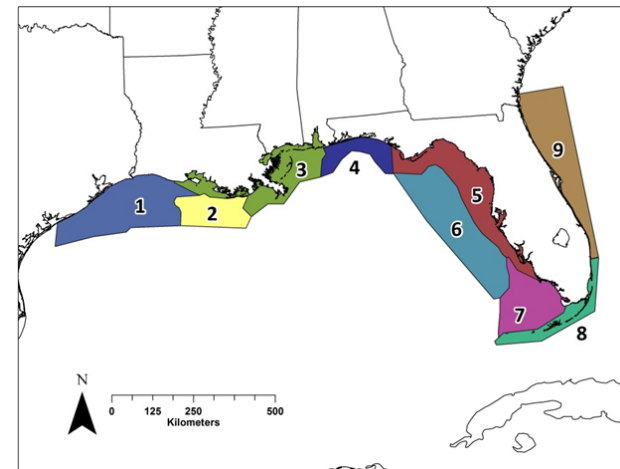
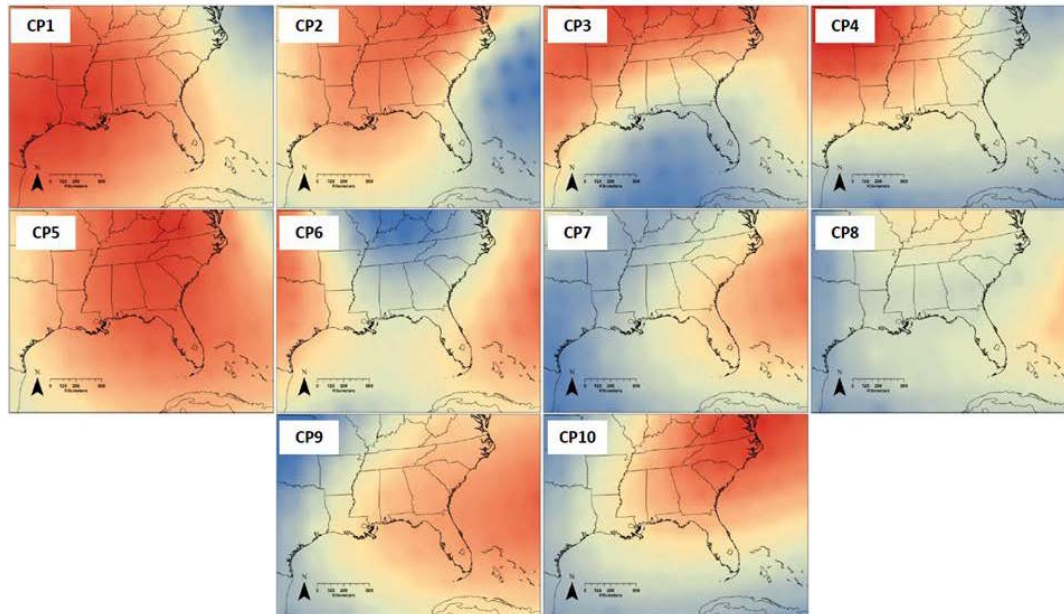
## Methods



WINTER										
REGION	CORRELATION OF ANOMALOUS CP FREQUENCIES BY WT AND REGION									
	CP1	CP2	CP3	CP4	CP5	CP6	CP7	CP8	CP9	CP10
1	-0.02	0.00	<b>0.22</b>	-0.06	-0.09	0.06	-0.04	-0.08	-0.05	0.09
2	<b>0.16</b>	-0.07	<b>0.16</b>	-0.09	-0.03	<b>0.19</b>	-0.07	-0.10	<b>-0.18</b>	-0.05
3	0.09	<b>-0.21</b>	<b>0.16</b>	-0.13	-0.02	<b>0.21</b>	0.01	0.00	<b>-0.15</b>	-0.07
4	0.09	0.04	0.06	-0.13	0.00	<b>0.21</b>	-0.07	-0.12	-0.05	-0.07
5	<b>0.21</b>	0.13	<b>0.15</b>	<b>-0.25</b>	-0.03	0.12	-0.12	-0.14	-0.11	0.00
6	<b>0.24</b>	<b>0.20</b>	0.08	-0.13	0.01	0.00	<b>-0.22</b>	-0.10	-0.13	0.03
7	<b>0.22</b>	<b>0.24</b>	<b>0.17</b>	-0.13	0.06	-0.06	<b>-0.21</b>	<b>-0.17</b>	<b>-0.15</b>	0.00
8	0.13	<b>0.25</b>	0.11	-0.10	0.01	-0.09	-0.13	-0.09	-0.05	-0.01
9	0.00	<b>0.35</b>	<b>0.21</b>	-0.07	0.07	-0.13	<b>-0.14</b>	-0.14	-0.07	0.00

Weekly frequency – Kd Index correlations; bold values are significant

## Regional Correlations: Circulation patterns



WINTER									
REGION	CORRELATION OF ANOMALOUS SSC FREQUENCIES BY WT AND REGION								
	DM	DP	DT	MM	MP	MT	MT+	MT++	TR
1	0.07	0.11	-0.04	-0.02	-0.06	-0.13	-0.10	0.01	<b>0.17</b>
2	<b>0.04</b>	0.21	<b>0.01</b>	<b>-0.04</b>	-0.11	-0.14	-0.14	<b>-0.02</b>	0.29
3	<b>-0.03</b>	<b>0.05</b>	0.07	<b>-0.02</b>	-0.13	-0.06	<b>-0.04</b>	<b>0.00</b>	0.29
4	0.08	0.04	0.03	0.03	0.07	<b>-0.14</b>	<b>-0.16</b>	-0.01	0.08
5	0.01	<b>0.14</b>	-0.03	<b>0.19</b>	<b>0.19</b>	<b>-0.27</b>	<b>-0.16</b>	<b>-0.19</b>	<b>0.29</b>
6	0.12	<b>0.16</b>	-0.01	<b>0.15</b>	<b>0.21</b>	<b>-0.26</b>	<b>-0.22</b>	<b>-0.23</b>	<b>0.22</b>
7	<b>0.30</b>	0.02	-0.05	0.08	0.11	<b>-0.29</b>	<b>-0.24</b>	0.09	<b>0.40</b>
8	<b>0.24</b>	-0.02	-0.07	0.03	0.04	<b>-0.20</b>	<b>-0.16</b>	0.05	<b>0.29</b>
9	<b>0.19</b>	-0.07	-0.06	0.08	<b>0.17</b>	<b>-0.24</b>	-0.04	-0.05	0.11

Weekly frequency – Kd Index correlations; bold values are significant

## Regional Correlations: weather types

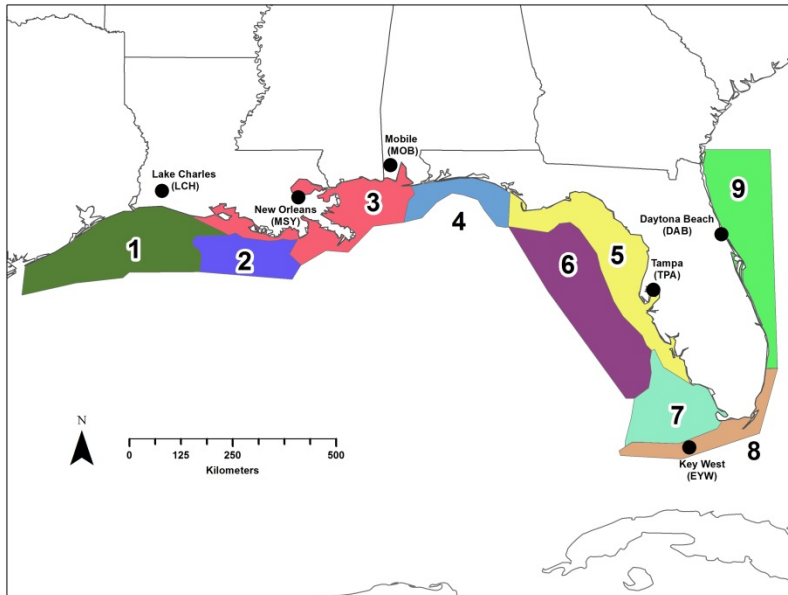


Abb.	Type
DM	Dry Moderate
DP	Dry Polar
DT	Dry Tropical
MM	Moist Moderate
MP	Moist Polar
MT(+, ++)	Moist Tropical (Plus, Plus-Plus)
TR	Transitional

25 mm			
0LAG	0	1	2+
R1	-0.05	0.04	0.44
R2	-0.02	0.06	0.02
R3	-0.02	0.01	0.16
R4	-0.06	0.09	0.29
R5	-0.04	0.10	0.20
R6	-0.03	0.08	0.21
R7	-0.02	0.06	0.14
R8	0.00	0.01	0.06
R9	-0.03	0.06	0.30

## Regional correlations: Heavy precipitation events

- Continued development of algorithms to predict the time series of *Kd index*
- More detailed analysis of spike *Kd index* “events”
- Validation on CZCS data, 1978-1986
- Development of full reconstruction, 1948-2013

## Future steps