Loop Current influence on the connectivity of the Gulf of Mexico

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Objective and methodology

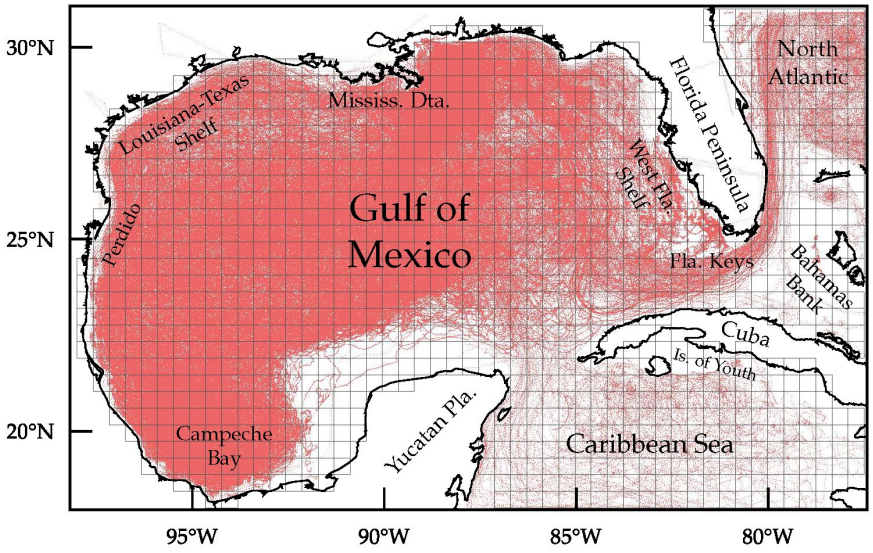
Evaluating the influence of the Loop Current on the connectivity of the Gulf of Mexico (GoM).

- From trajectories of surface drifters in the GoM
- Using the Transfer Operator (transition matrix) a tool to study the behavior of dynamical systems
- Application to the dispersion of Red Tide on the West Florida Shelf from in-situ data

Data sets

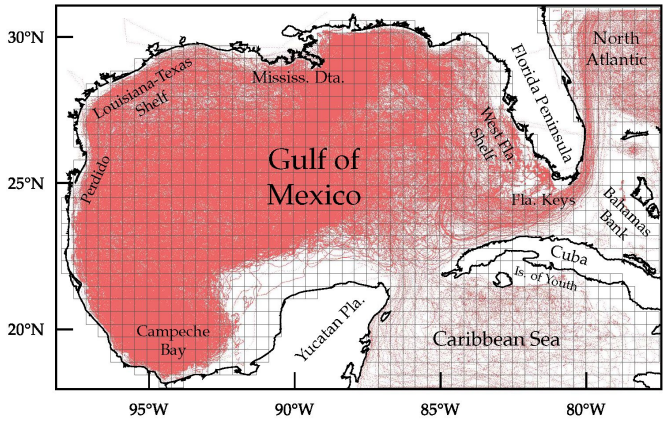
Historical drifter trajectories

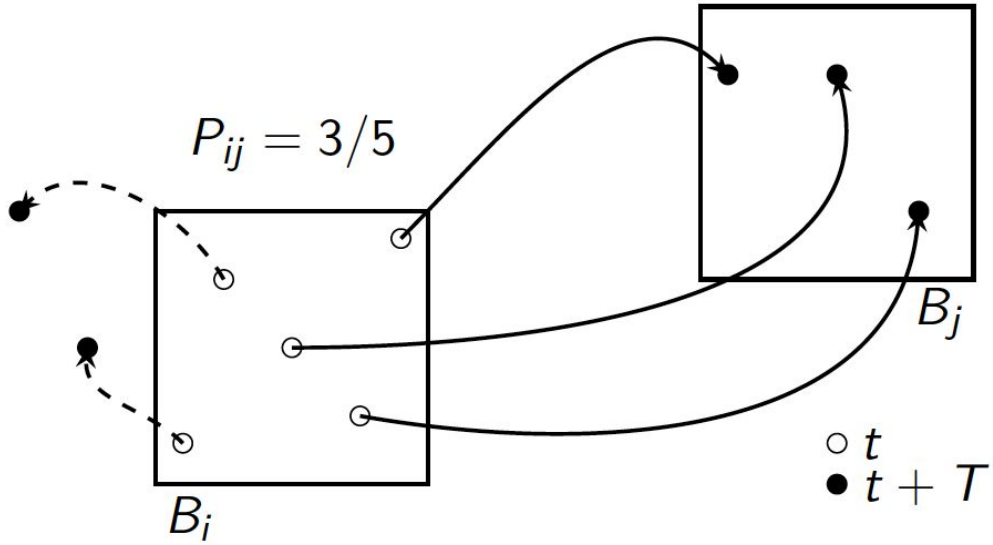
- 3500+ drifter trajectories from several sources 1992–2019 (CARTHE[1], GDP[2], CICESE, SCULP, AOML[1], USCG[1])
- Data publicly available
  1. Gulf of Mexico Research Initiative Information & Data Cooperative (GRIIDC)
  2. Physical Oceanography Division Global drifters (PhOD GDP)



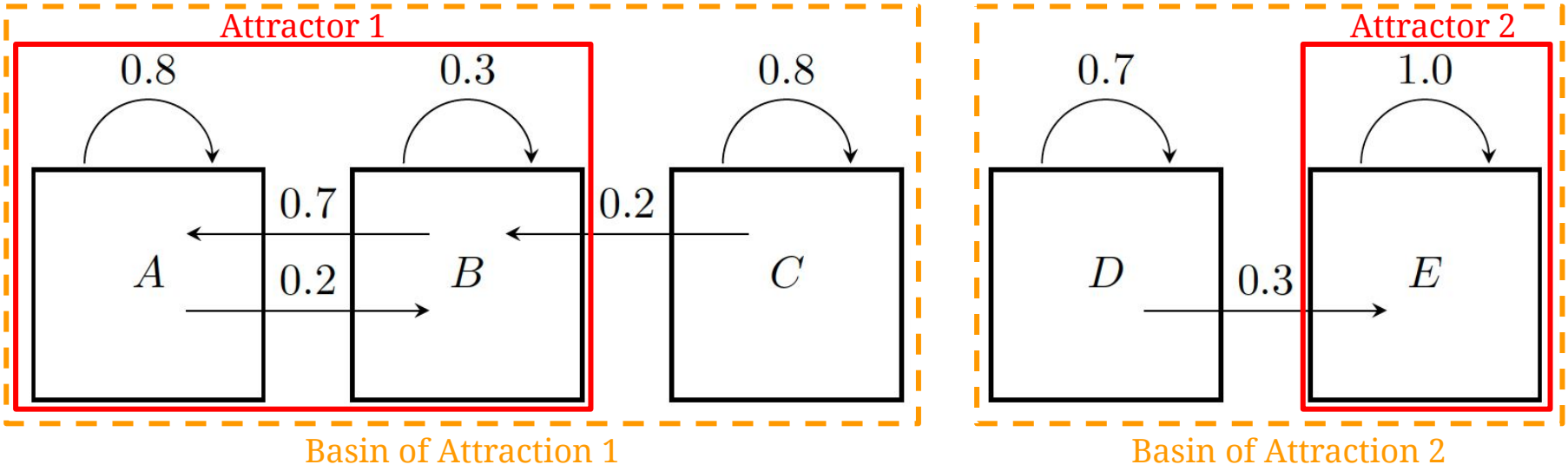
Transition matrix

$$P_{ij} \approx \frac{\#\text{ points in } B_i \text{ at } t \text{ that evolve to } B_j \text{ at } t+T}{\#\text{ points in } B_i \text{ at } t}$$





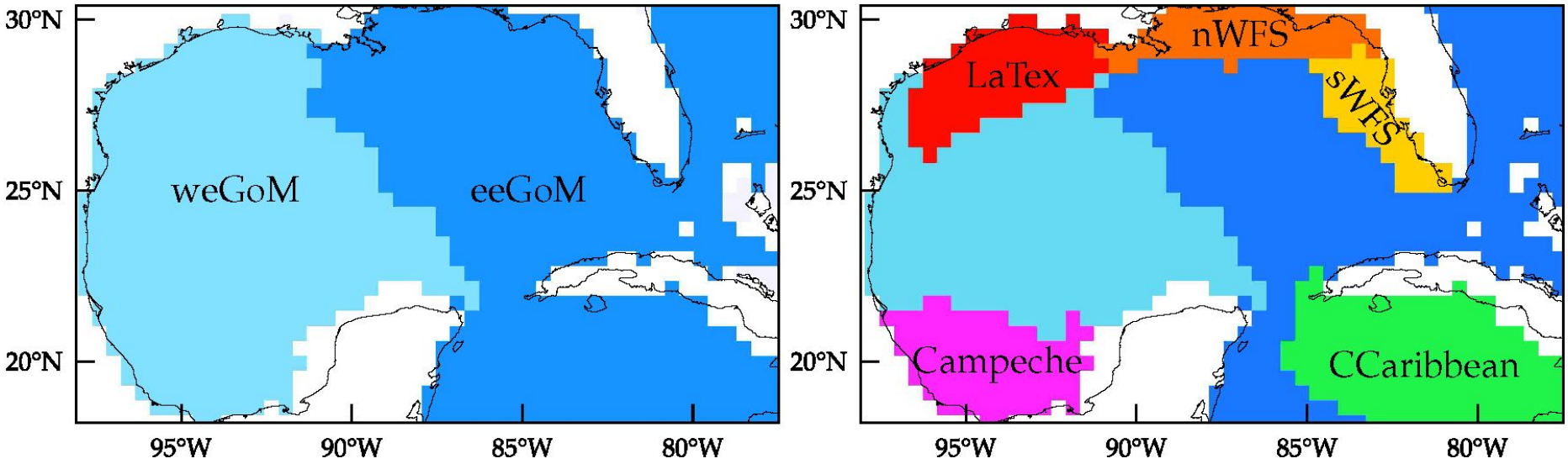
Example with a simple 5 bins/states problem



$\mathcal{P} =$

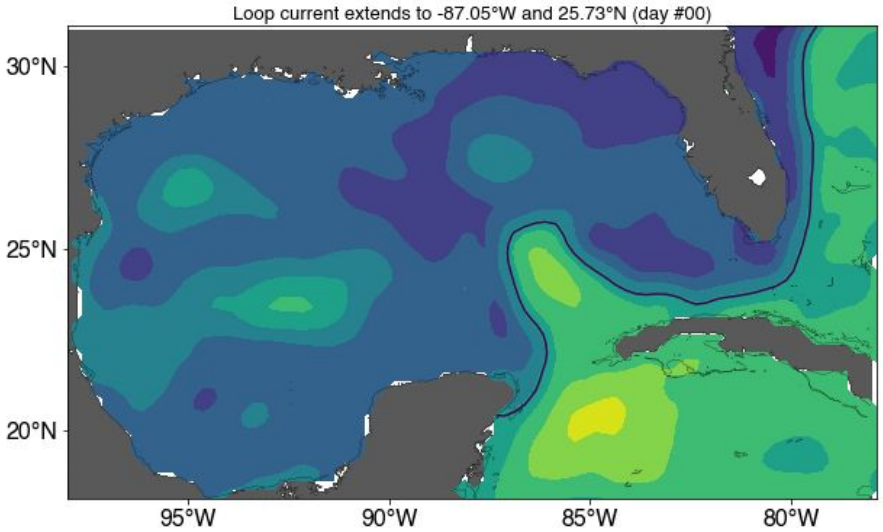
	A	B	C	D	E
A	0.8	0.2	0	0	0
B	0.7	0.3	0	0	0
C	0	0.2	0.8	0	0
D	0	0	0	0.7	0.3
E	0	0	0	0	1.0

Lagrangian geography of the GoM (Miron, 2017)



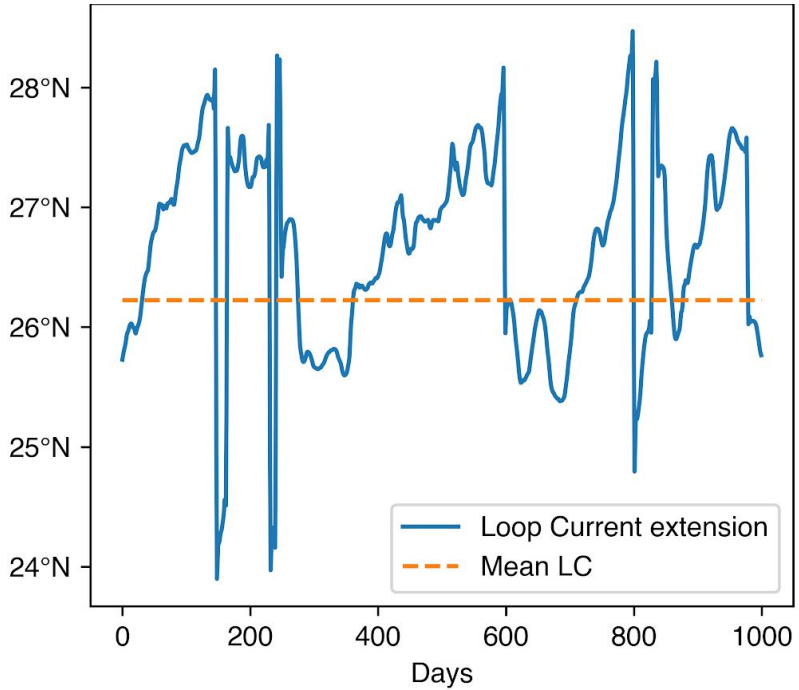
LC state time series (following Leben, 2005)

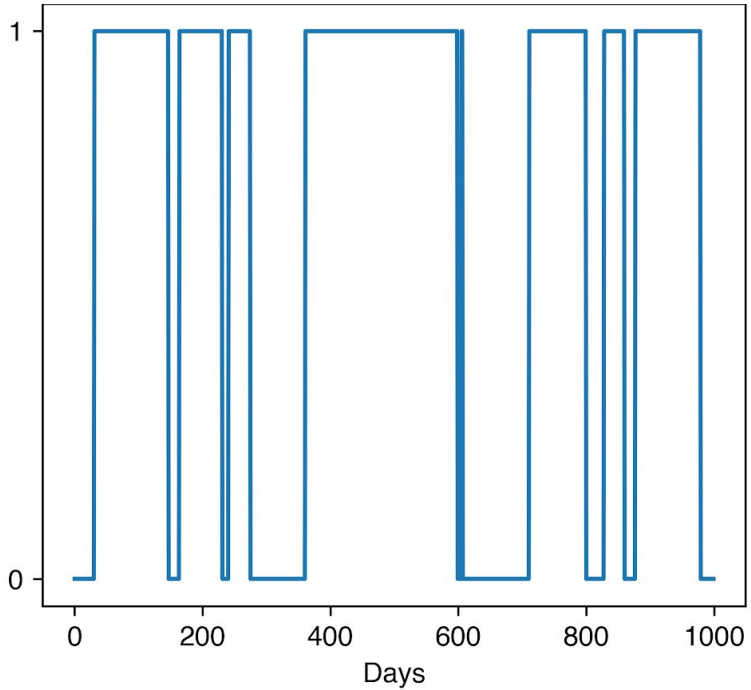
- 1/4° Absolute Dynamic Topography (1992–2019 from Copernicus)
- Remove daily mean value from ADT to eliminate thermal expansion (depth of more than 200m)
- Extract the LC has the and filter the 17-cm contour of the Loop Current
- Calculate the maximum latitude



Loop Current state time series

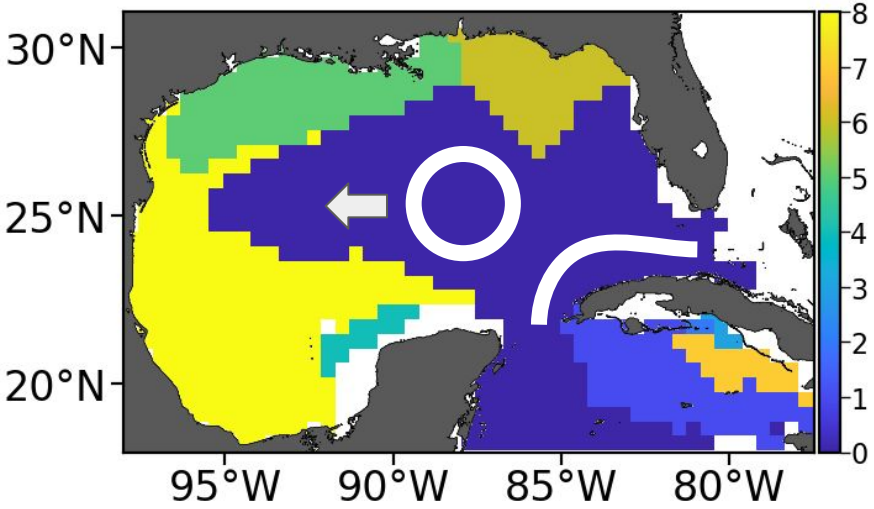
Split drifter trajectories into two groups: retracted LC (0) and extended LC (1).



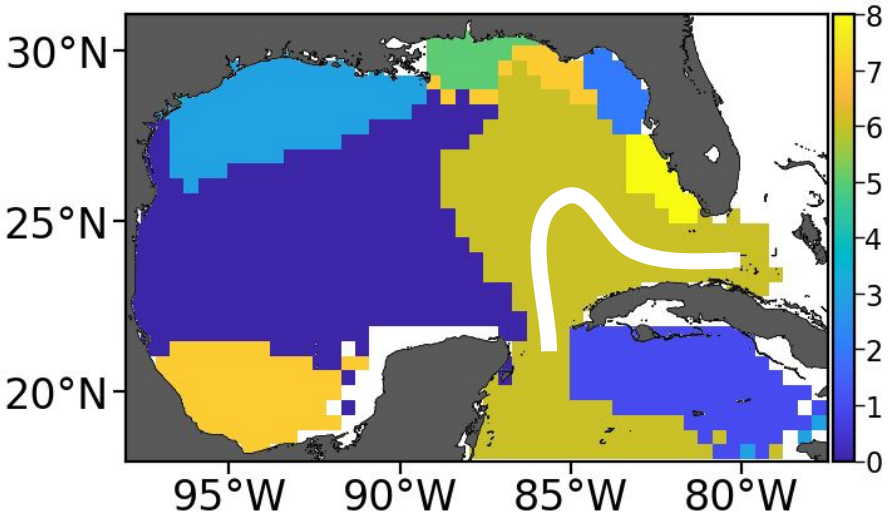


Lagrangian geography: Cross-shelf Transport Barrier

Retracted LC

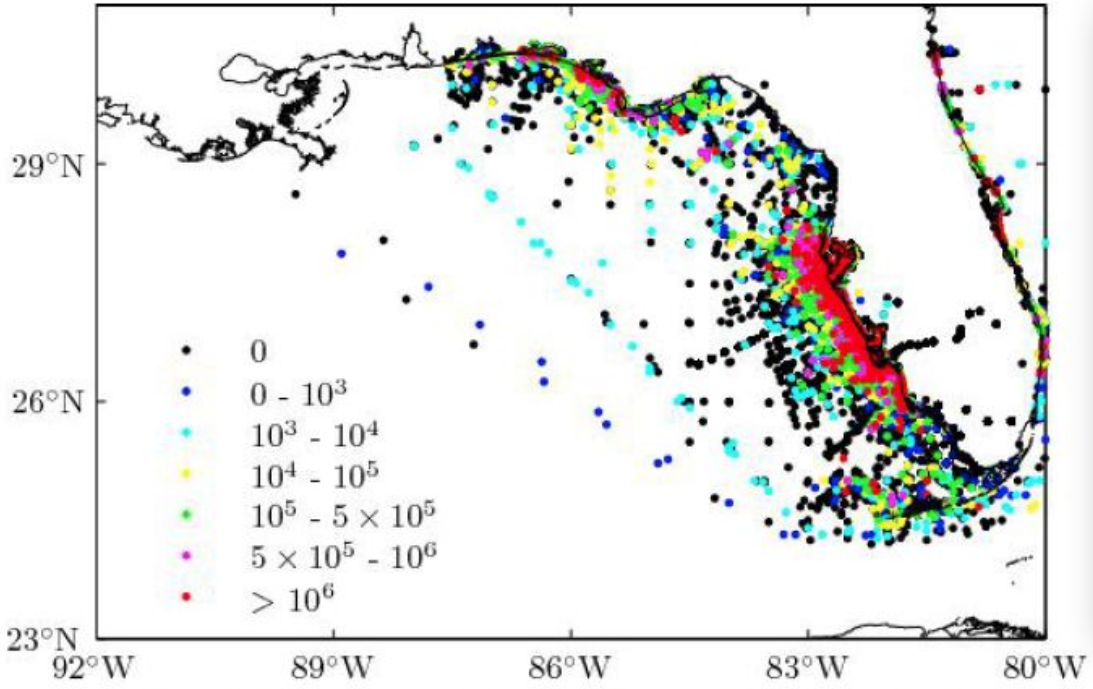


Extended LC

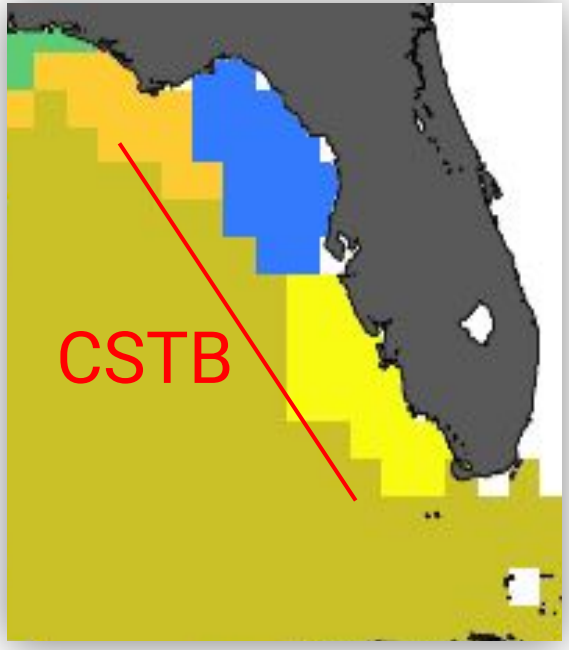


CSTB correlated with the LC extension (Hetland et al. 1999, Olascoaga et al. 2006 and Olascoaga 2010).

K. brevis density (associated with Red tide)



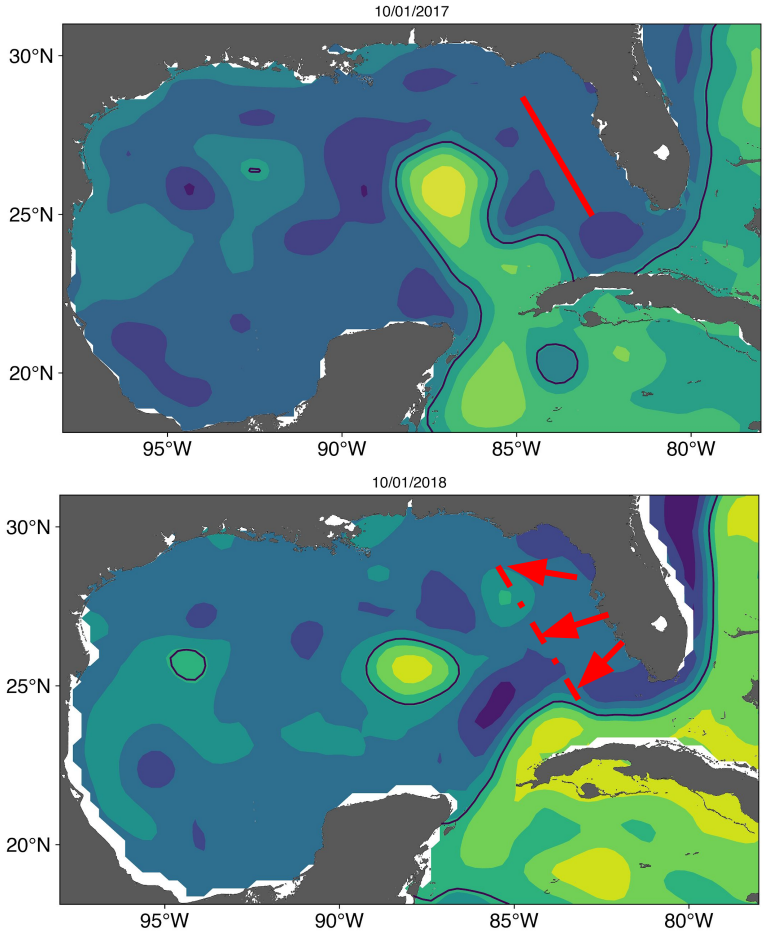
1954–2002 record of *K. brevis* cell counts [cells per liter].



Red Tide event 2017-2018

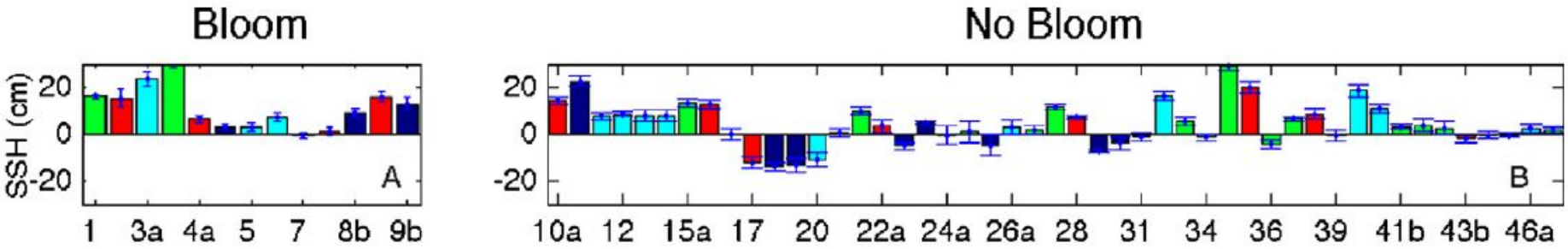
- **October 2017:** Red tide began on the WFS (LC Extended)
- **LC Ext. April–August 2018**: Eddy Revelle's separated, reattached and finally separated.
- **September 2018:** LC is retracted which allow for the spreading of Red Tide
- **October 2018:** Red Tide reached Miami and the West Palm Beach area

Support the correlation of the Cross-Shelf transport barrier with the state of the LC.



Agreement with historical analysis (1993–2007)

Bloom occurs **only** when the LC is extended.



Maze et al. (2015). Historical analysis (1993–2007) of environmental conditions during Florida Red Tide

Conclusion

- LC state critically influence the connectivity of the WFS
  - **extension:** Transport Barrier that can trap nutrients from rivers (lake Okeechobee) needed for Red Tide blooming.
  - **retraction**: spreading offshore and connection to the east Florida coast

The LC state is not the only factor of Red tides (high °T and nutrients, low PSU) but blooming mostly occurs during its extension.

References – bit.ly/pmgom2020

Jupyter notebook to calculate the LC time series on Github at https://github.com/philippemiron.

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