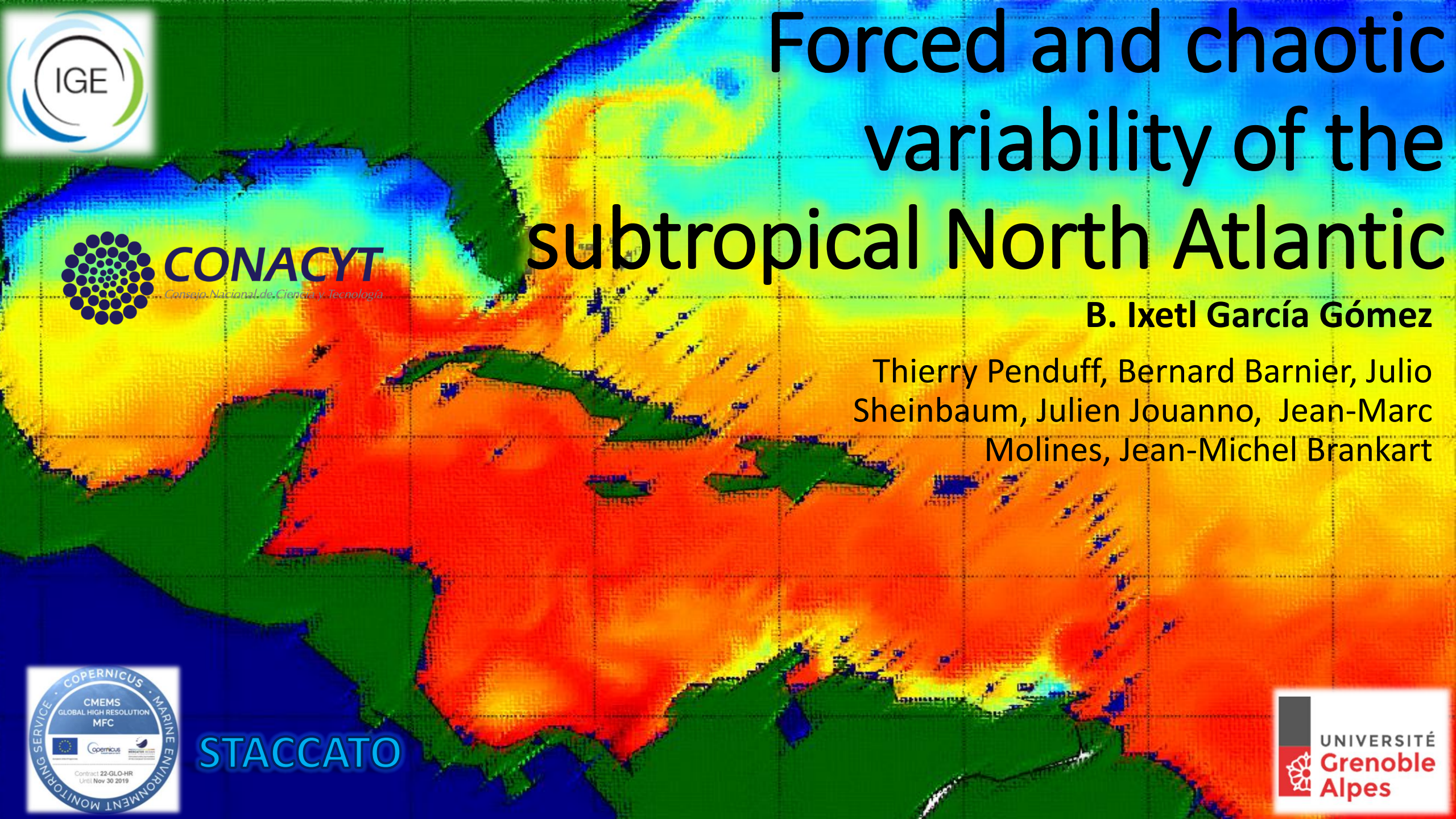


Forced and chaotic variability of the subtropical North Atlantic

B. Ixetl García Gómez

Thierry Penduff, Bernard Barnier, Julio Sheinbaum, Julien Jouanno, Jean-Marc Molines, Jean-Michel Brankart

IGE

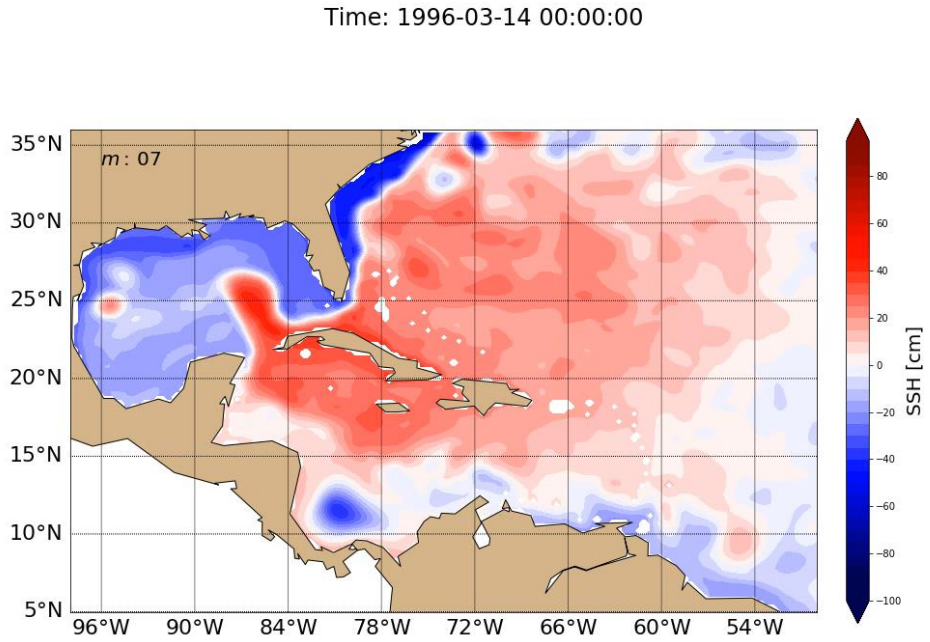
CONACYT
Consejo Nacional de Ciencia y Tecnología

COPERNICUS MARINE ENVIRONMENT MONITORING SERVICE
CMEMS
GLOBAL HIGH RESOLUTION MFC
Contract 22-GLO-HR
Until Nov 30 2019

STACCATO

UNIVERSITÉ Grenoble Alpes

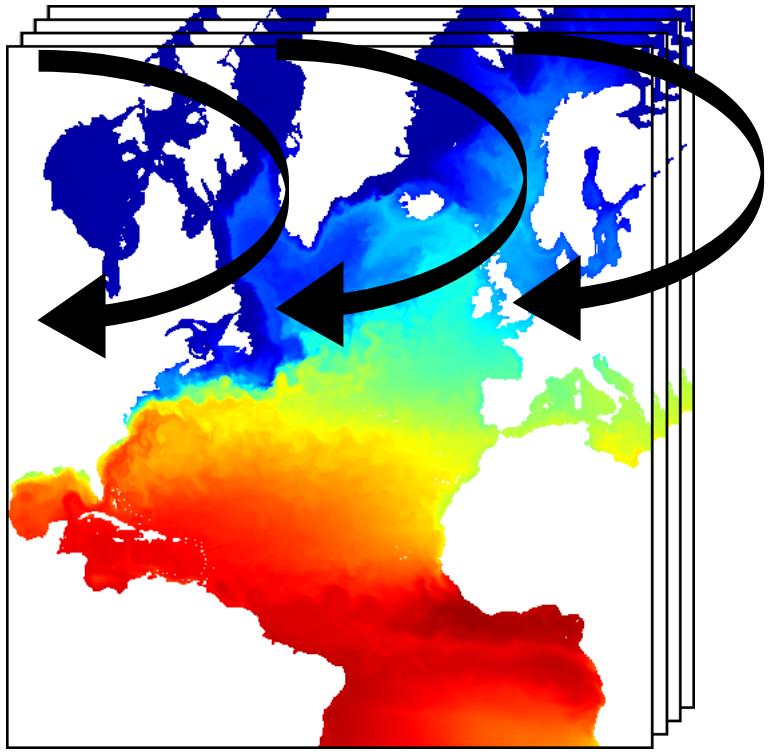
Motivation



Variability of Gulf of Mexico: Atmospherically- forced or Chaotic?

- The Gulf of Mexico (GoM) a basin with strong turbulent activity.
- Loop Current/ Eddy shedding / Shelf Interaction
- Forced: Chang& Oey,2010; Chang & Oey, 2013;
- Chaotic: Lugo- Fernandez, 2007; Cherubin et al., 2006;
- Both: Sturges et al., 1993; Nowlin et al., 2000; Cardona & Braccco,2016.

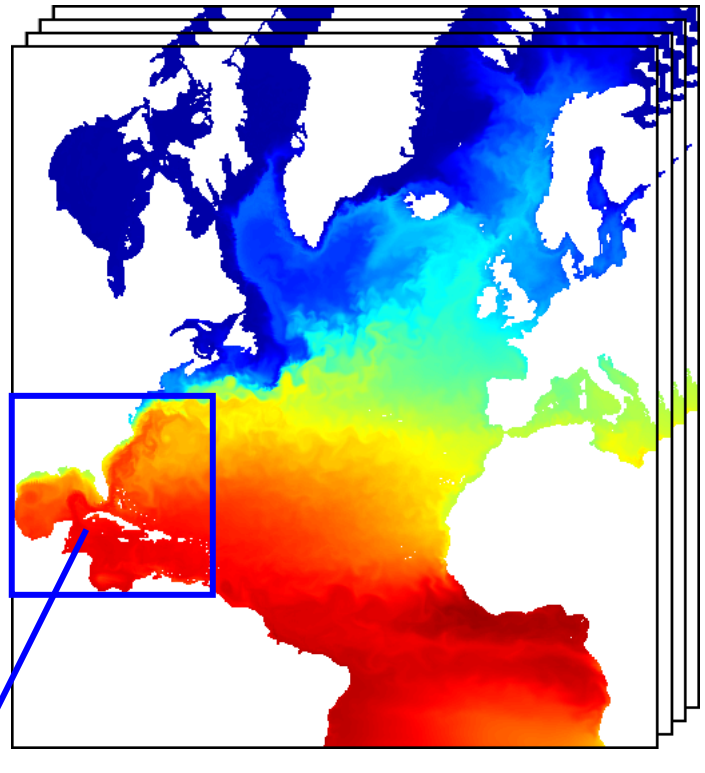
DATA



50-member 20-year
NATL025 ensemble run
OCCIPUT Project
1993-2012

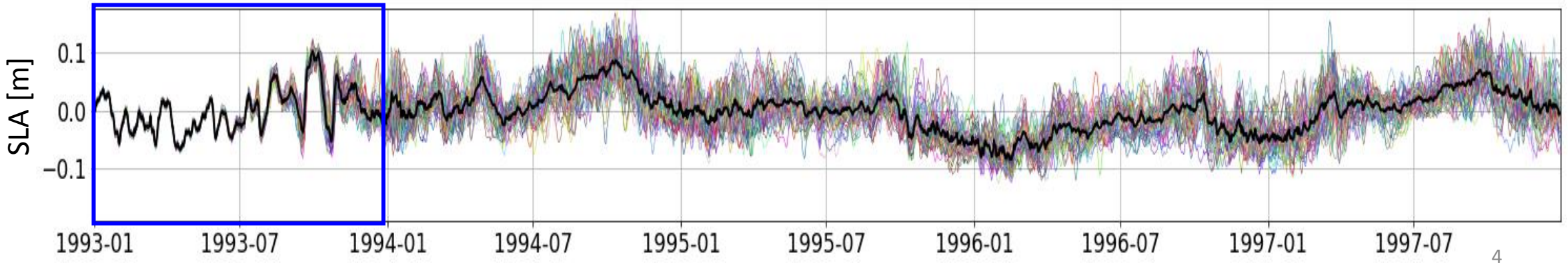
- Same atmospheric forcing.
(6h- interannual)

DATA



50-member 20-year
NATL025 ensemble run
OCCIPUT Project
1993-2012

- Same atmospheric forcing
- Same initial conditions
- Stochastic perturbation



Results

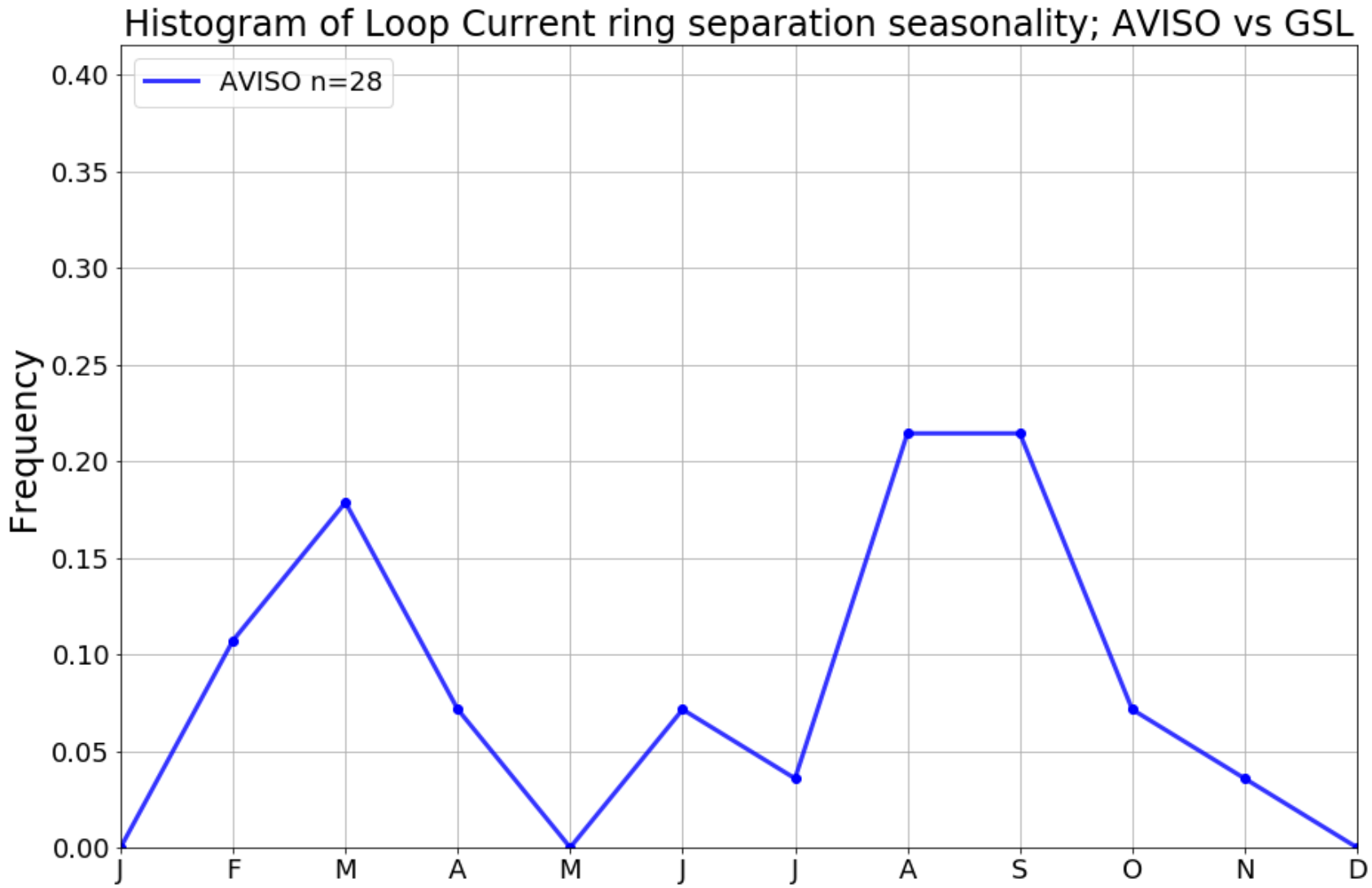
Model assessment: the Loop Current shedding

Loop Current and Volume exchanges across the boundaries of the Gulf of Mexico

Contrasted dynamical regimes in the Gulf of Mexico.

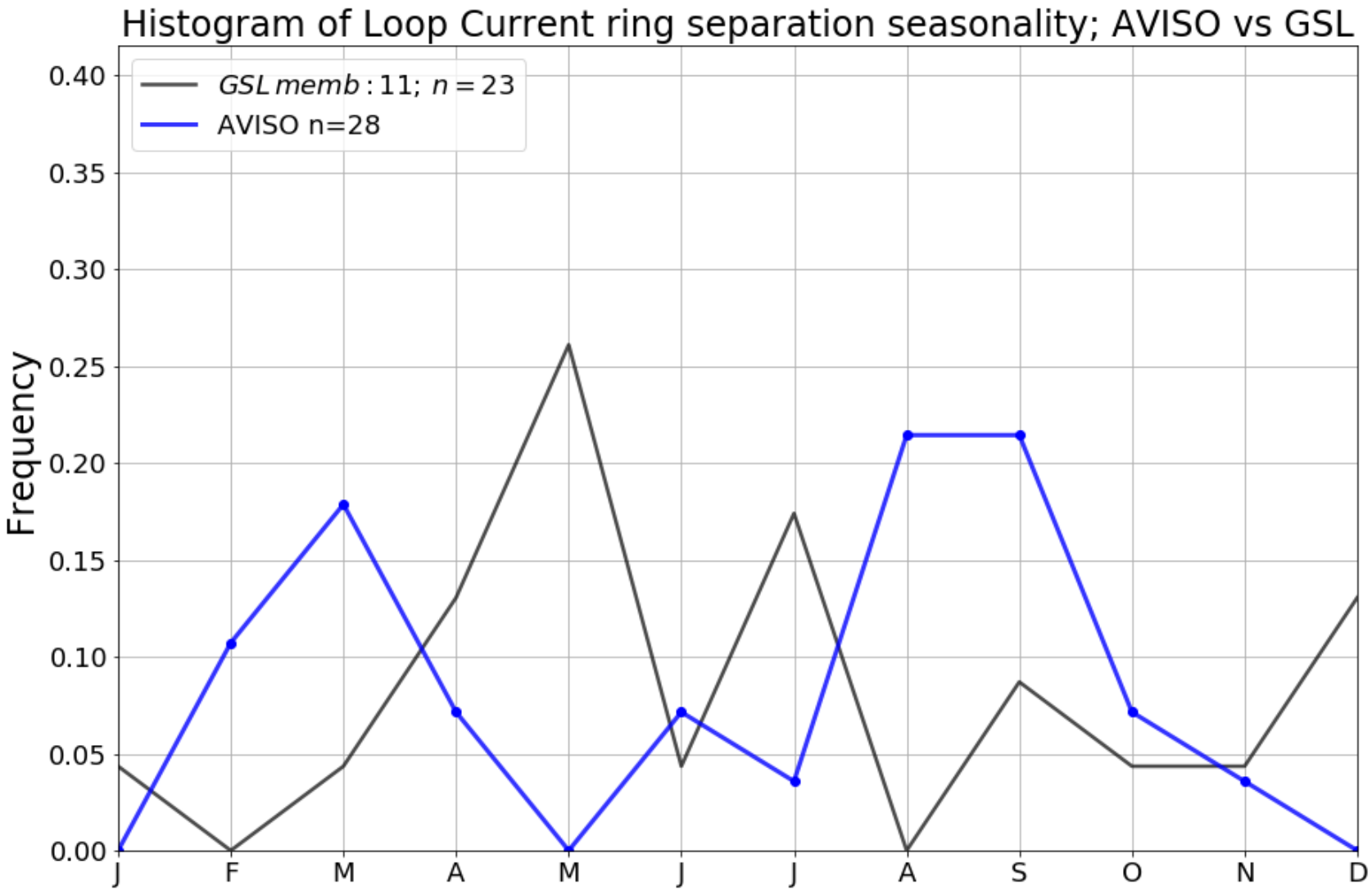
Chaos propagating in time and in space.

Loop Current shedding: Observations

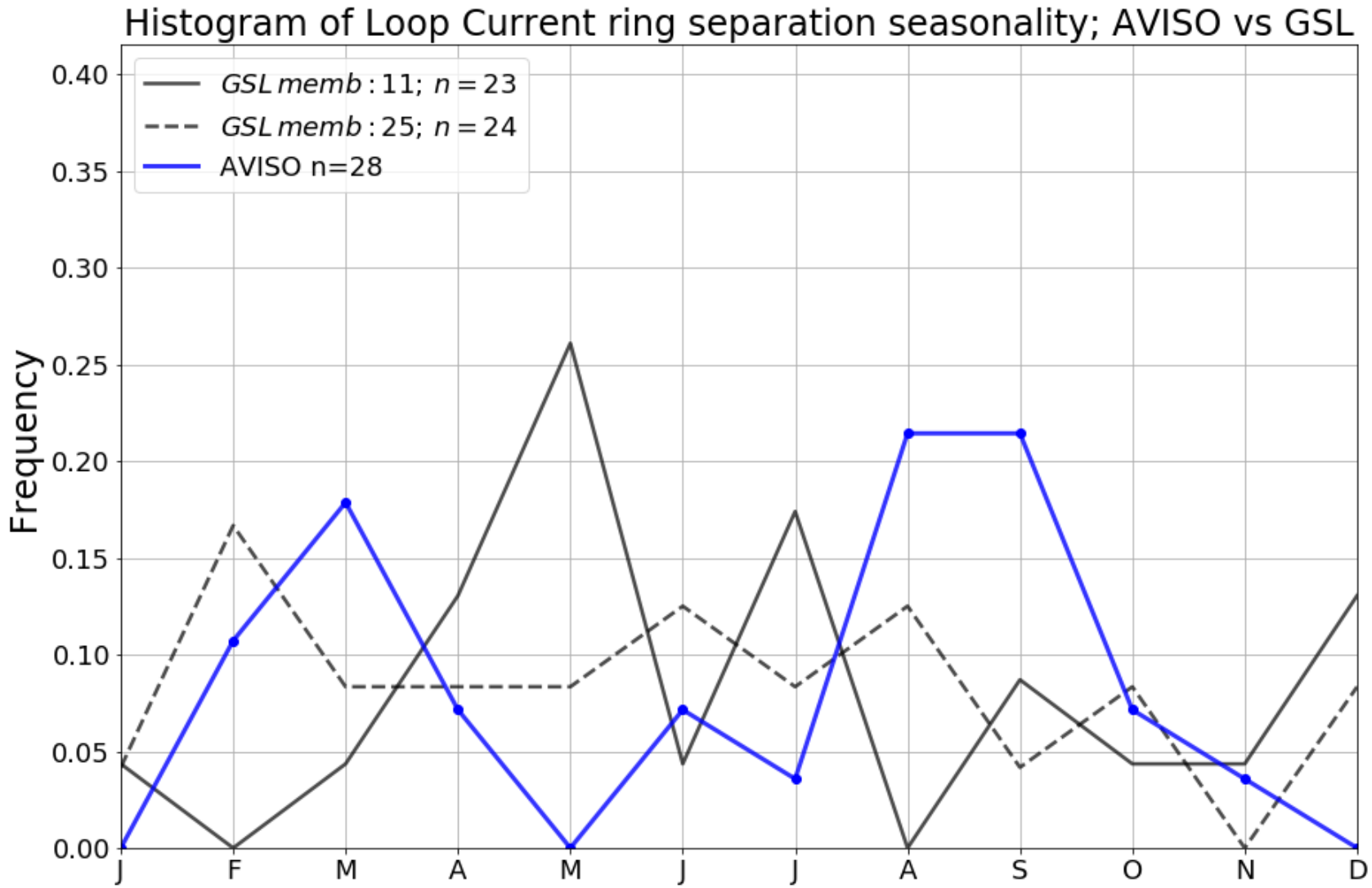


1993-2012

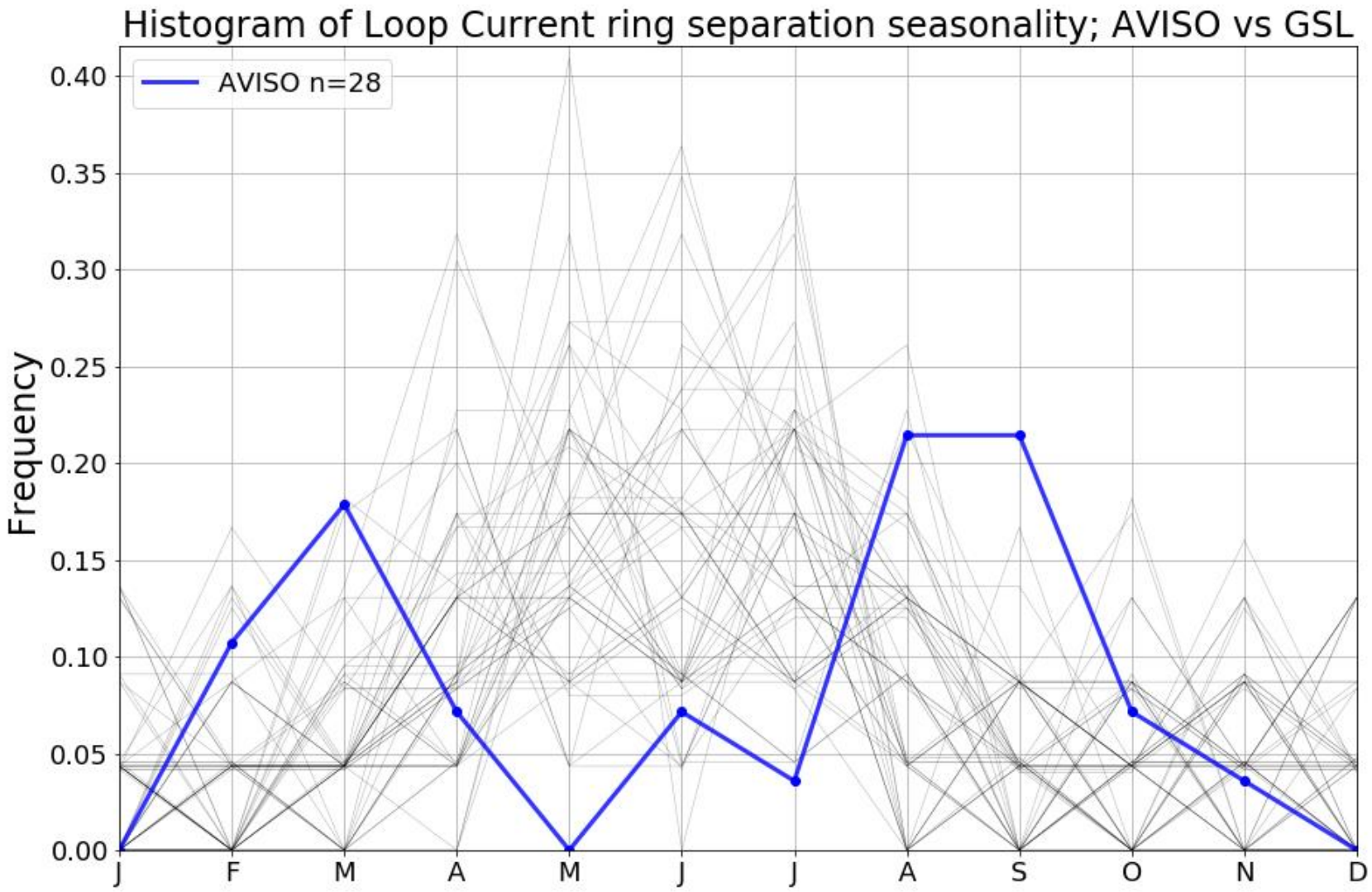
Loop Current shedding: Observations vs Simulations



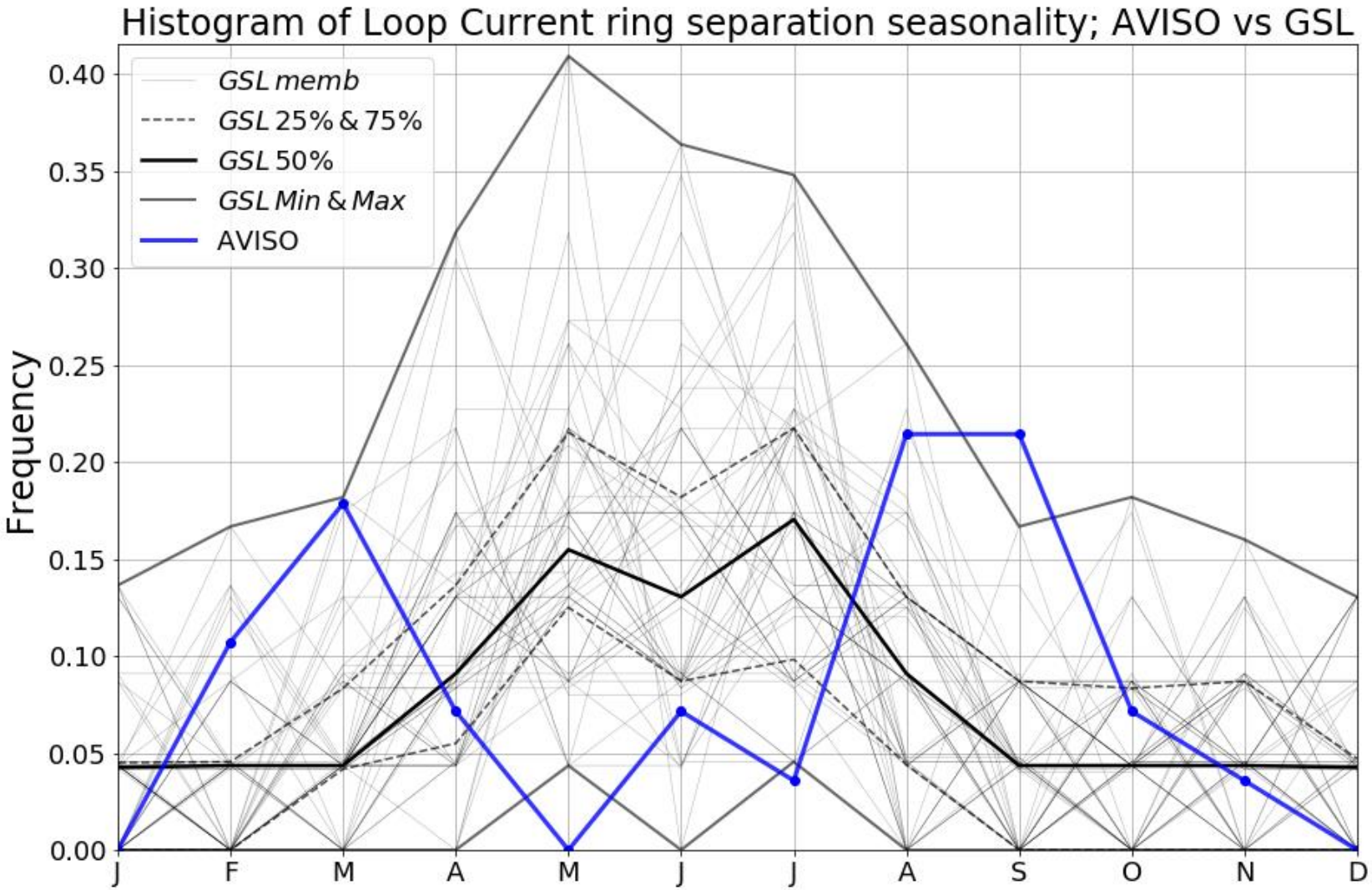
Loop Current shedding: Observations vs Simulations



Loop Current shedding: Observations vs Simulations



Loop Current shedding: Observations vs Simulations



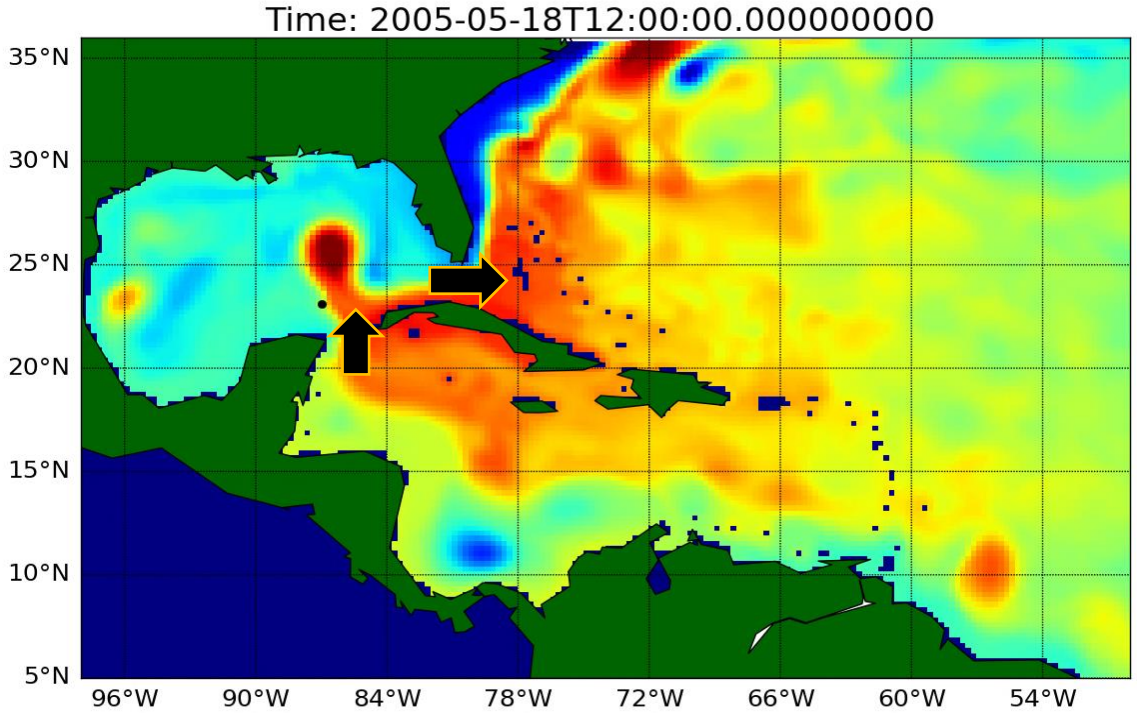
Results

Loop Current and Volume exchanges across the boundaries of the Gulf of Mexico

Contrasted dynamical regimes in the Gulf of Mexico.

Chaos propagating in time and in space.

Volume exchanges across the boundaries of the Gulf of Mexico

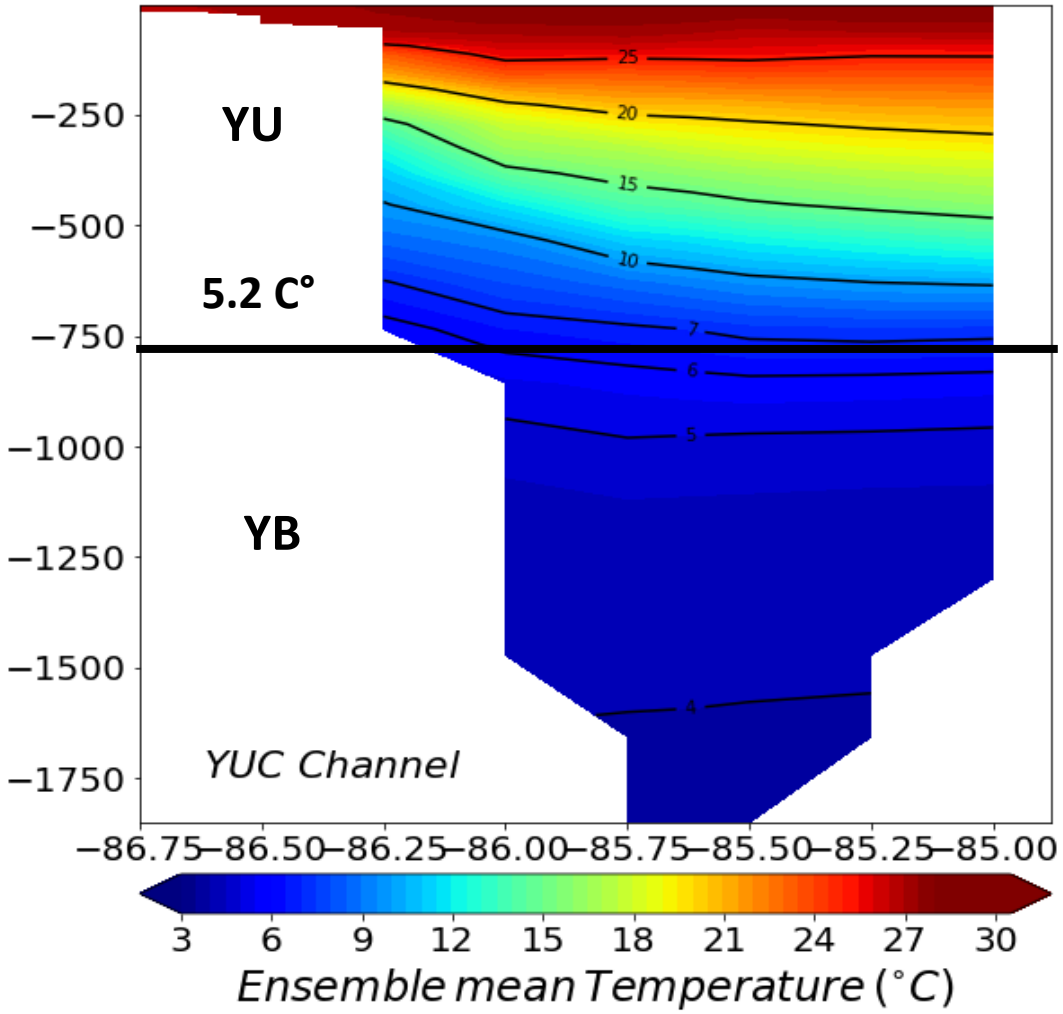


- What is the relation between the variability of the LC, with the in and out of water volumes (Yucatan channel and Florida straits transports)?

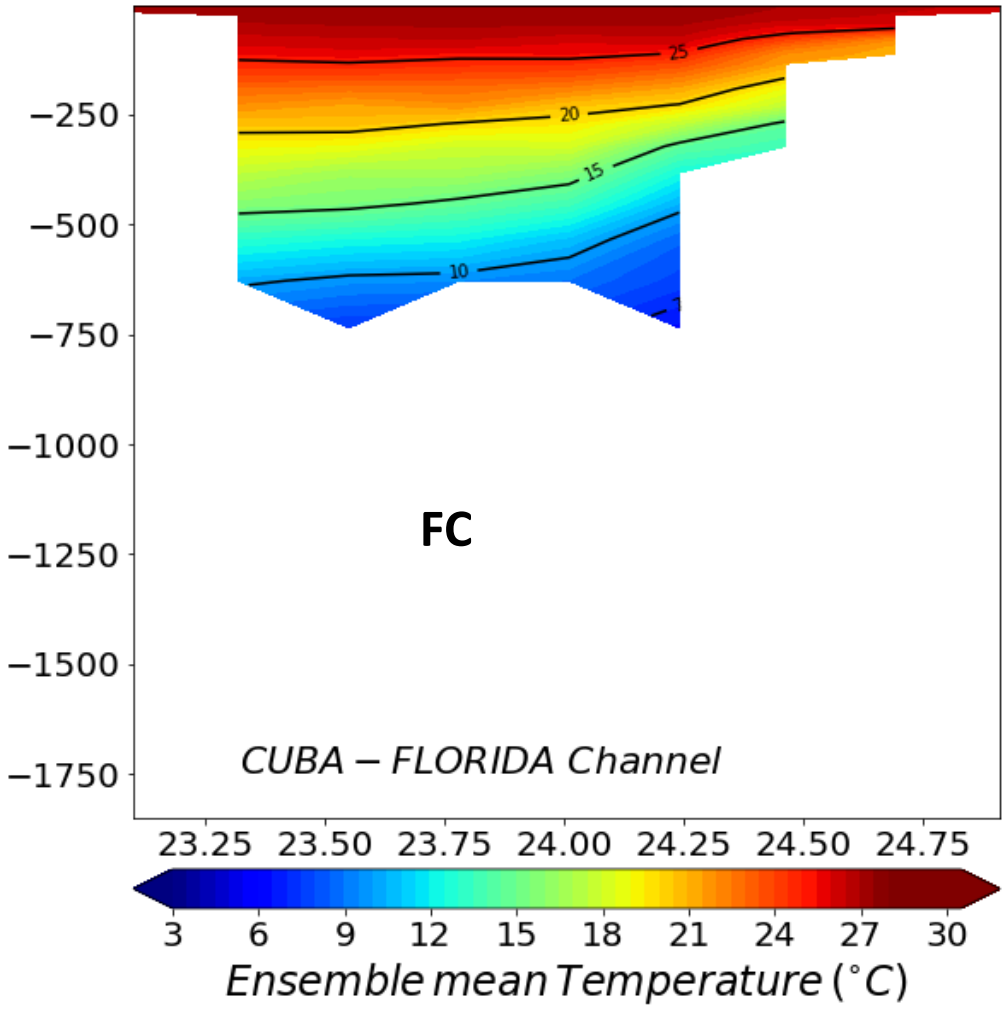
- Transports through:
  - Yucatan Channel
  - Florida-Cuba strait

Sections

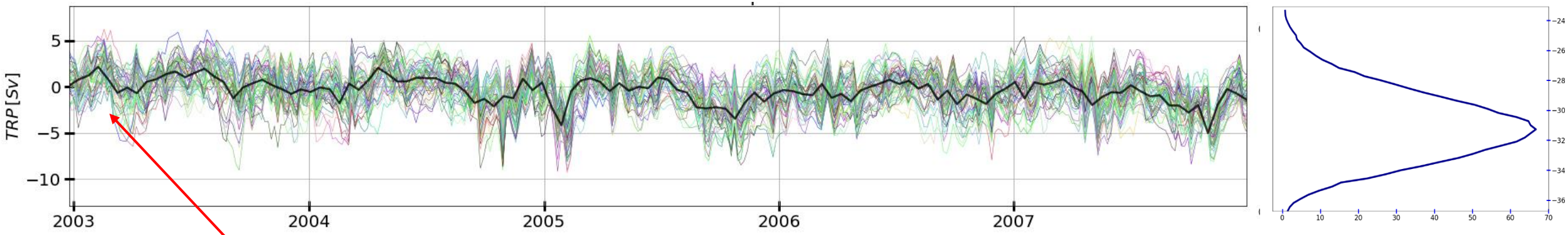
Yucatan Channel



Florida- Cuba Strait



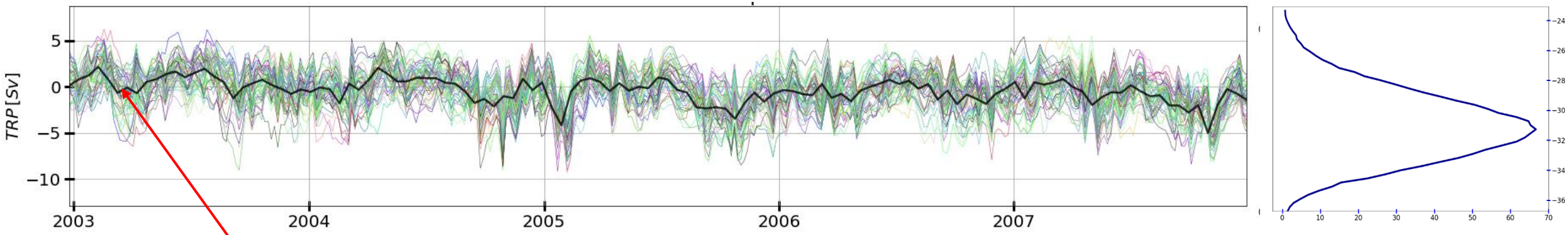
Definitions and important points



- Total variability
- Forced variability
- Intrinsic variability

Leroux et al, 2018

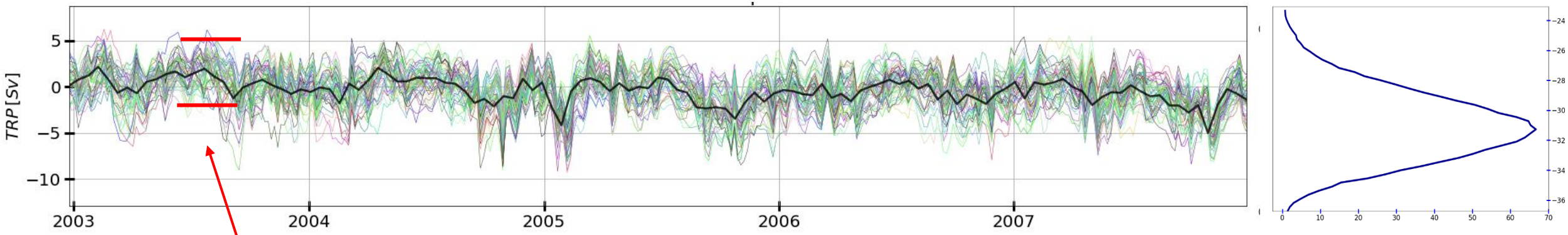
Definitions



- Total variability
- Forced variability
- Intrinsic variability

Leroux et al, 2018

Definitions



- Total variability

-

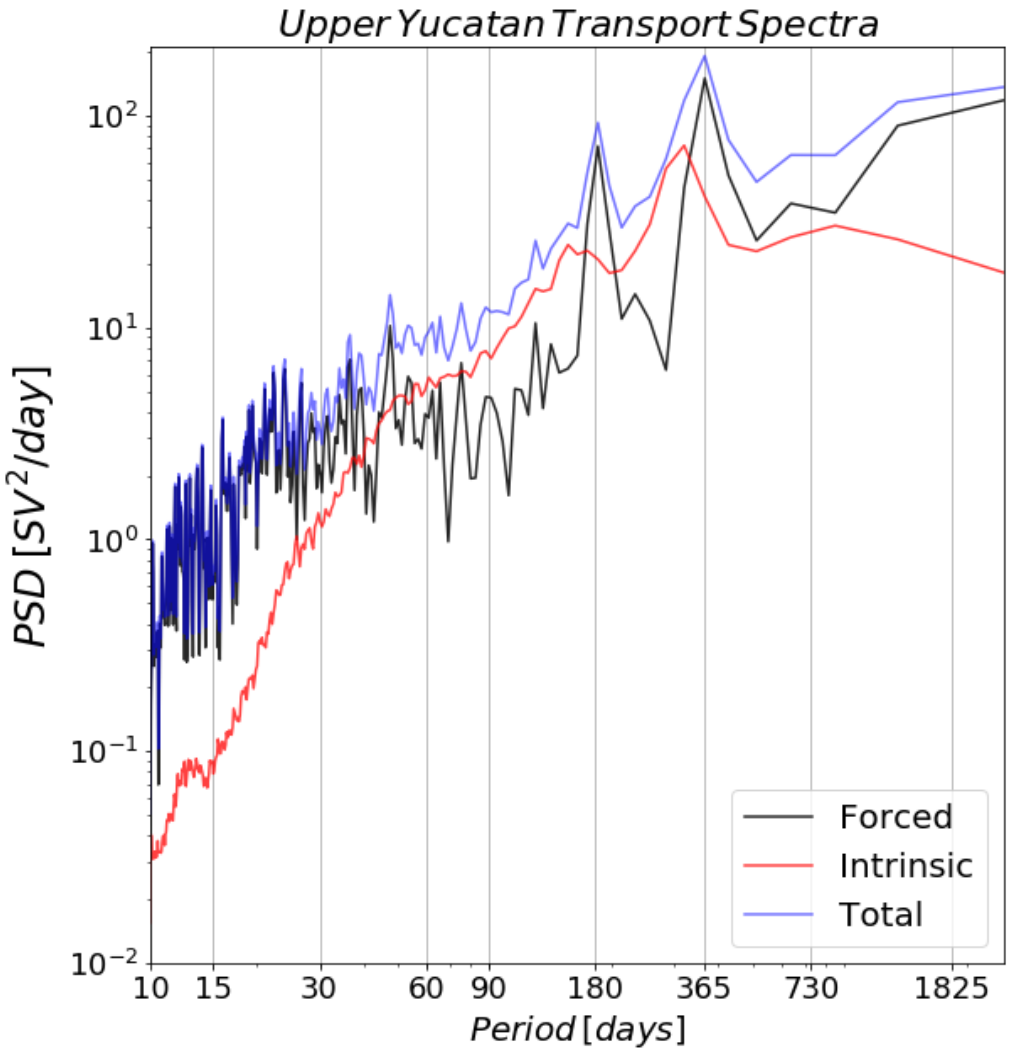
- Forced variability

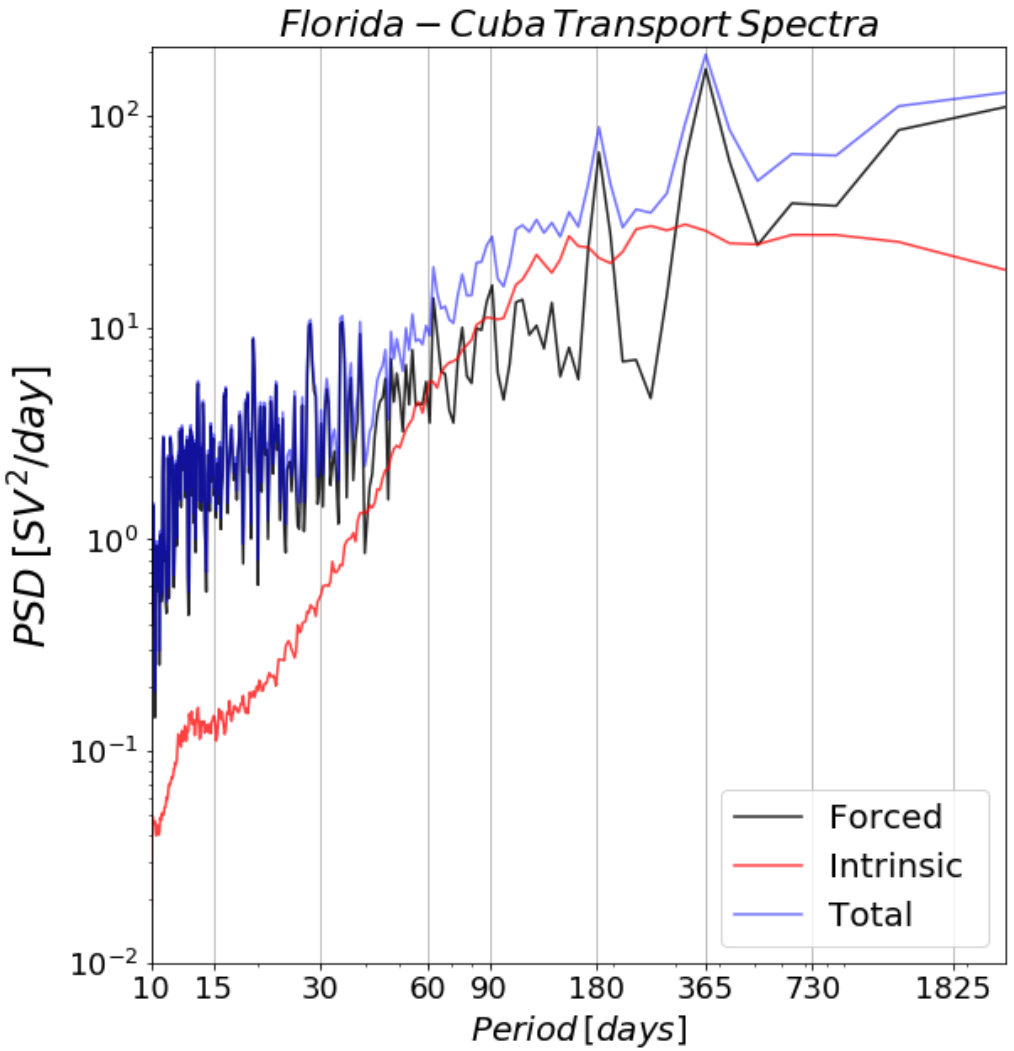
=

- Intrinsic variability

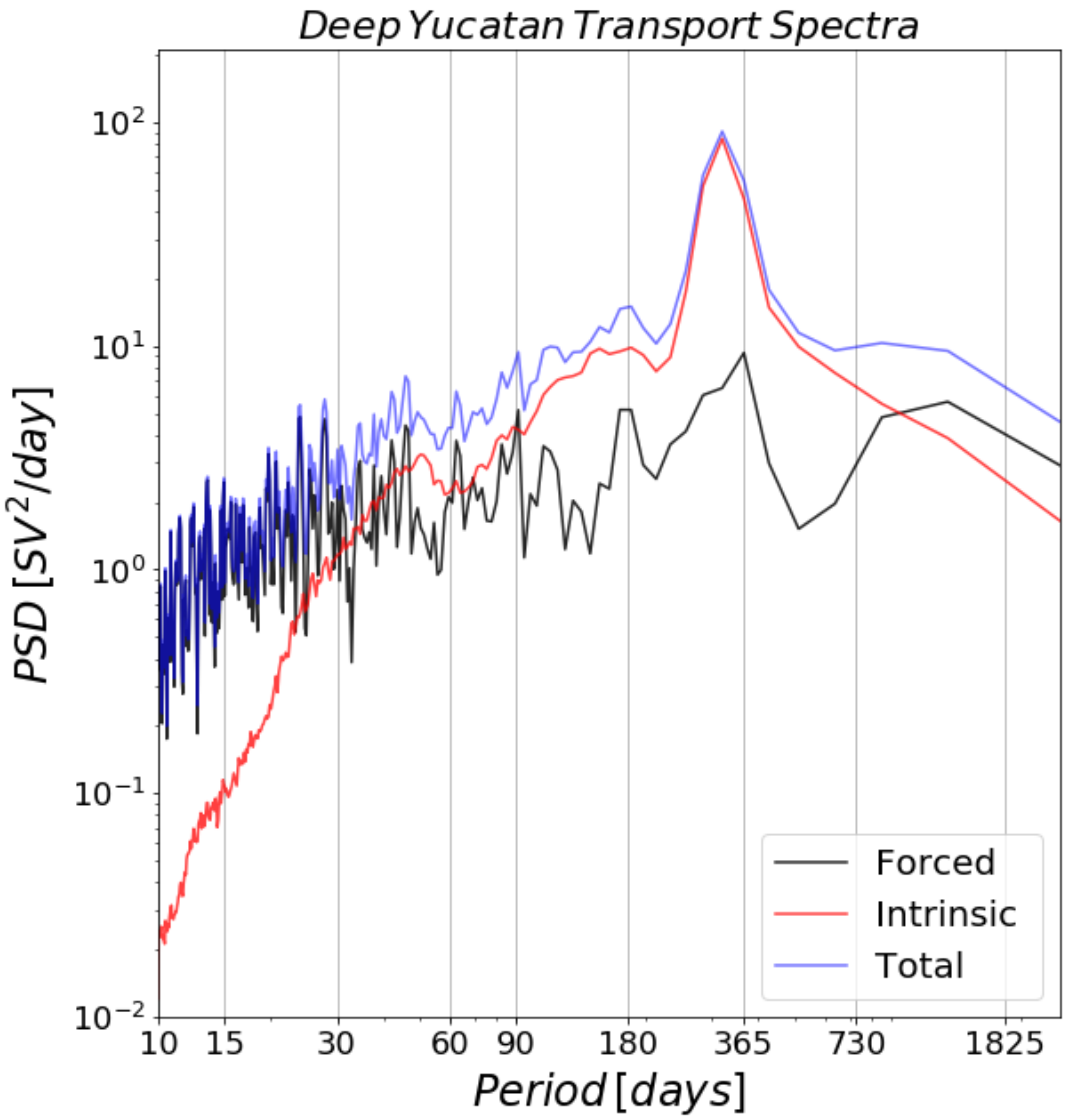
Leroux et al, 2018

Spectra: Total, Forced and Intrinsic variability

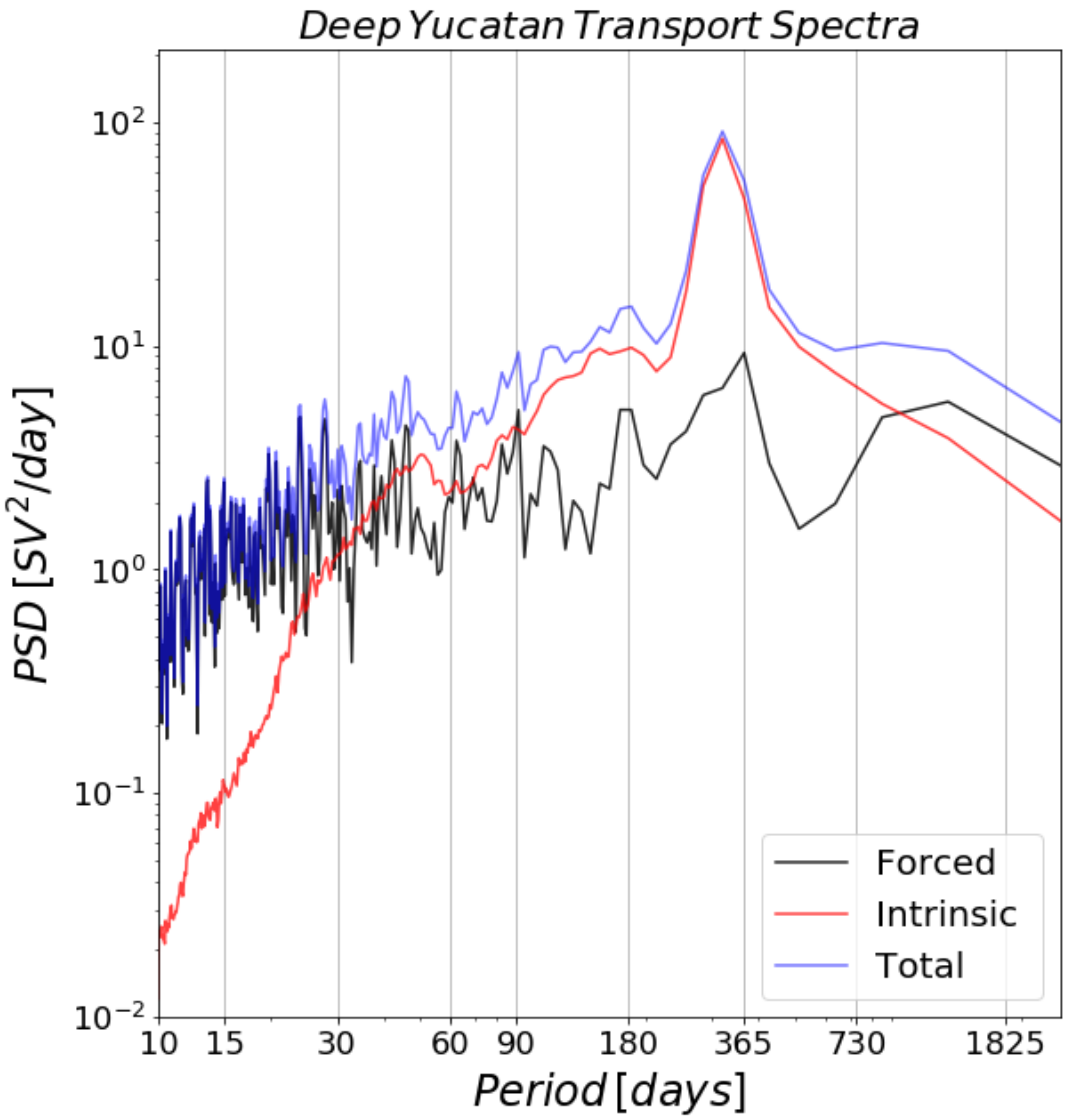


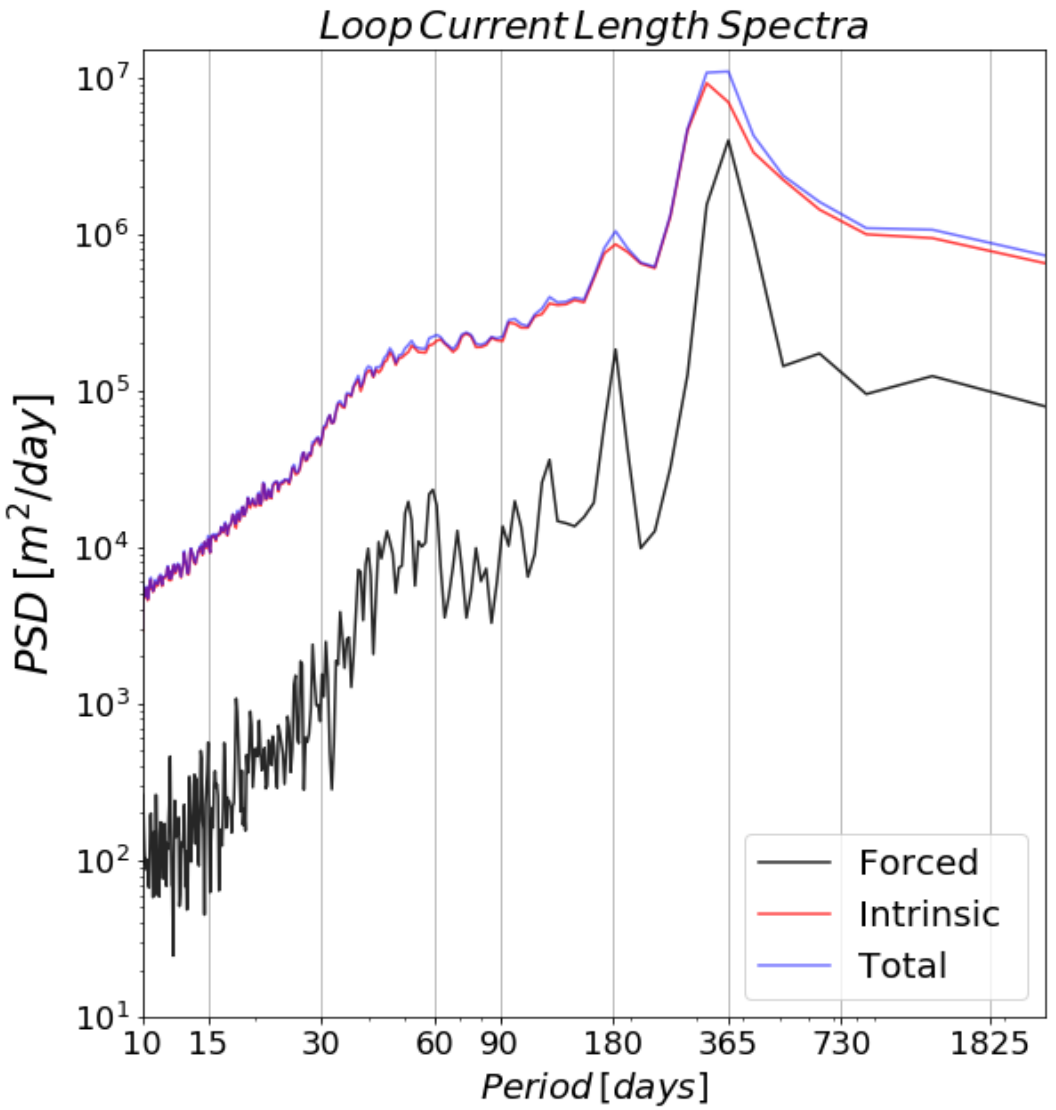


Spectra: Total, Intrinsic and Forced variability

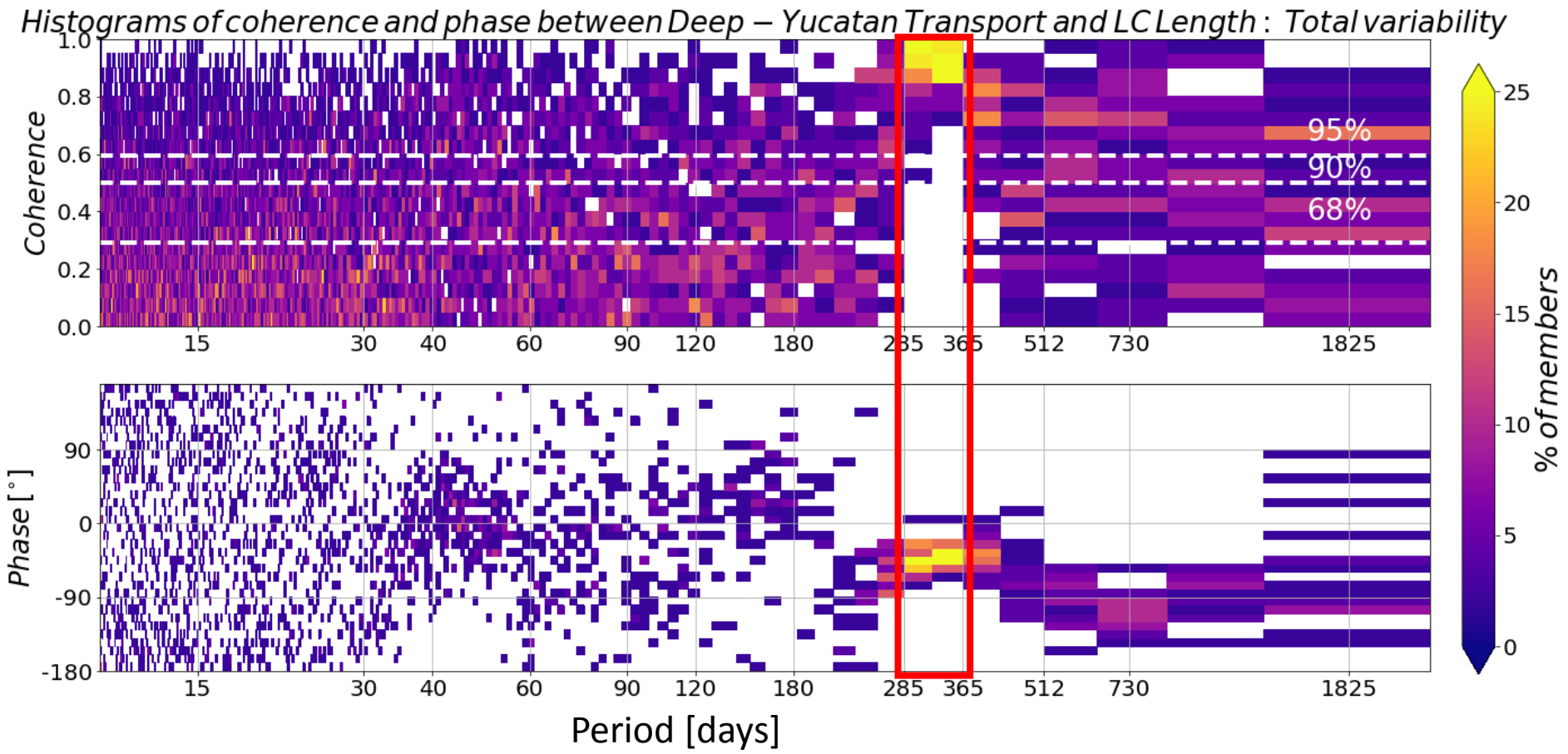


Spectra: Total, Intrinsic and Forced variability





Histograms of Coherence and phase: YB vs LC



- Maximum coherence ~320 days.
- LC extension leads YB by 30-45 days.

Results

Loop Current and Volume exchanges across the boundaries of the Gulf of Mexico

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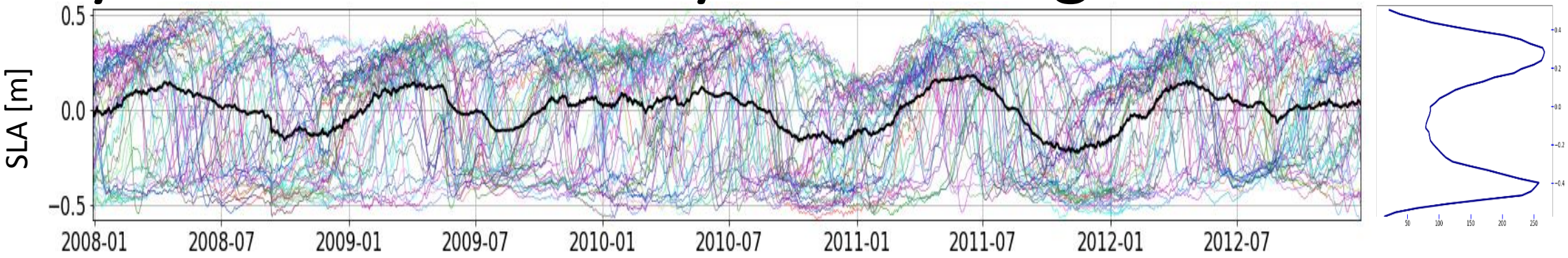
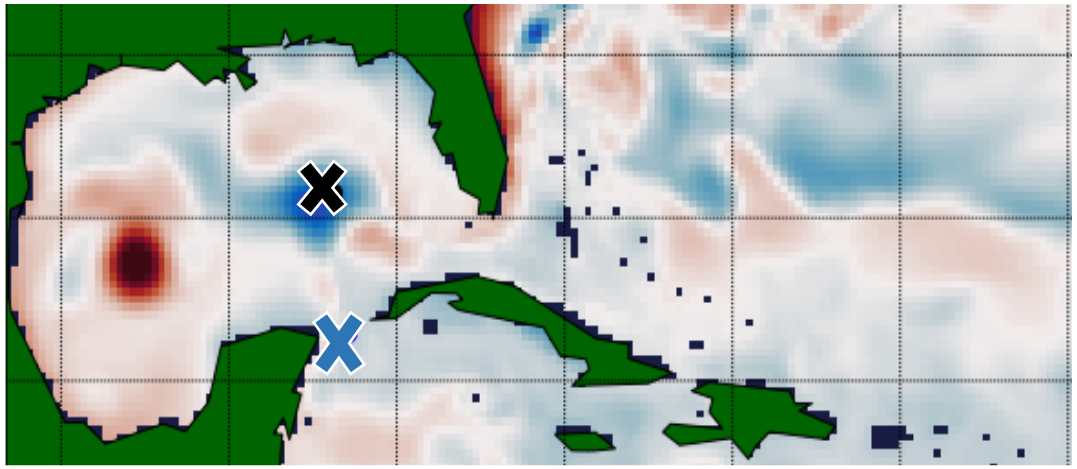
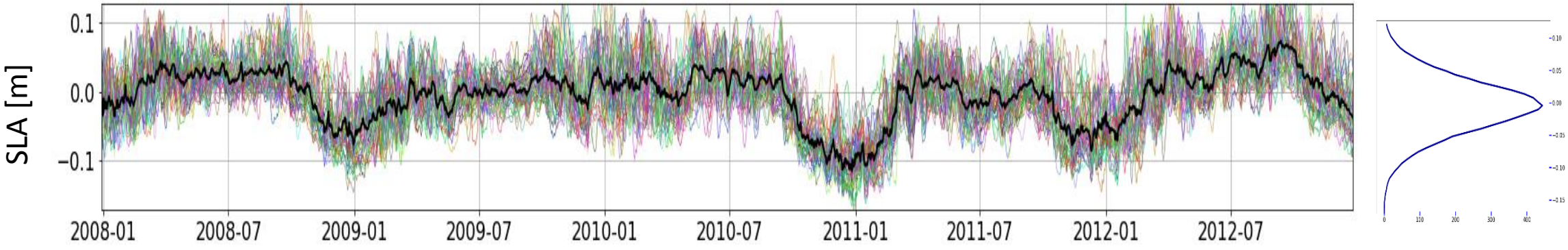
Chaos propagating in time and in space.

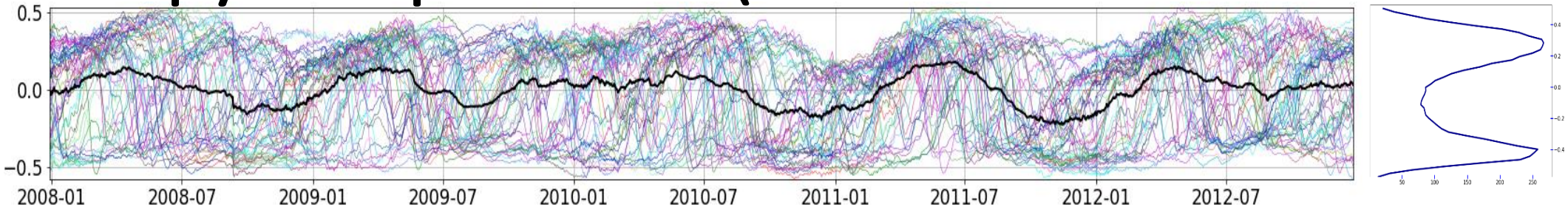
Daily SLA: contrasted dynamical regimes







Entropy computation (Shannon Information theory)



- Climatological PDF (k events) ➔ Climatological deciles (N=10) ➔ **Climatological ENTROPY**

$$S_{clim}(x,y) = -\sum_{i=1}^{N} p_i log_2(p_i) = log_2(1/10)$$

- Daily PDF(t) (50 events) ➔ Climatological deciles (N=10) ➔ **"Instantaneous" ENTROPY**

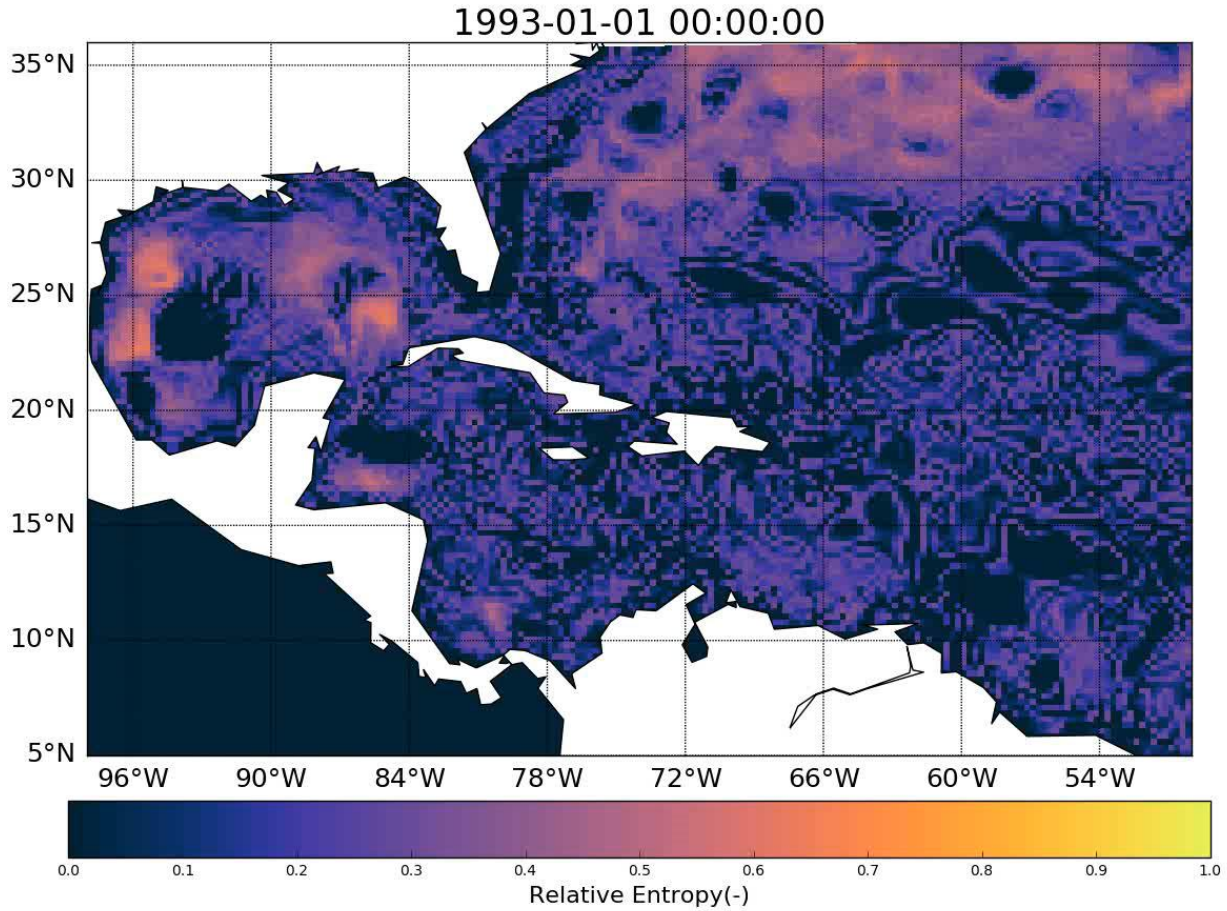
$$S_t(x,y,t) = -\sum_{i=1}^{N} p_i(x,y,t) log_2(p_i(x,y,t))$$

- **We define the Instantaneous normalized entropy varies between 0 and 1, no gaussian assumption, time dependance .**

$$S(x,y,t) = S_t / S_{clim}$$

Time–varying entropy

5-day mean normalized entropy (jan 1993 –> dec 2012)



$S(x, y, t)$

0 **1**

None — **Disorder/chaos** — Max

Max — **Atmospheric Forcing** — None

- Intrinsic variability
- propagating minima/maxima

Summary

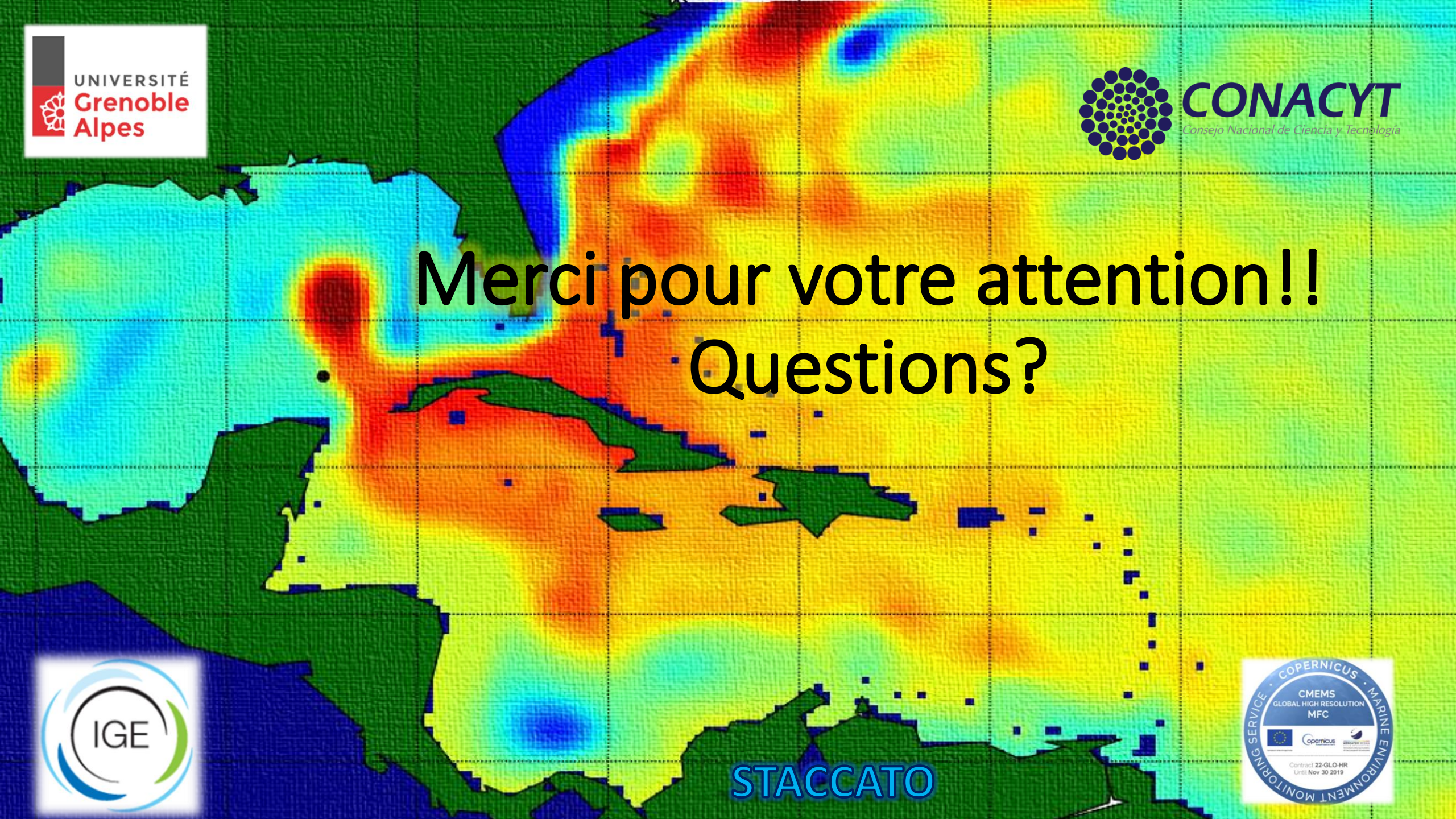
- LC shedding seasonality:
  - Model and Observations in good agreement.
  - Observational statistics not robust yet

- GoM inflows and outflows: highly chaotic at different time scales(monthly - interannual).

- Important link between YB and LC; LC influences the Deep inflows-outflows of Yucatan Channel

Summary

- LC variability: non-Gaussian ⟶ New metrics : Entropy.
- Entropy shows: space and time atmospheric modulation of the ocean chaos.
- Ensemble statistics, metrics and methods ⟶ study forced and chaotic ocean variabilities ⟶ contribution to prediction system.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Merci pour votre attention!!
Questions?
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