Real-time in-situ tracking of Lagrangian coherent structures in a coastal region

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Lagrangian Coherent Structures

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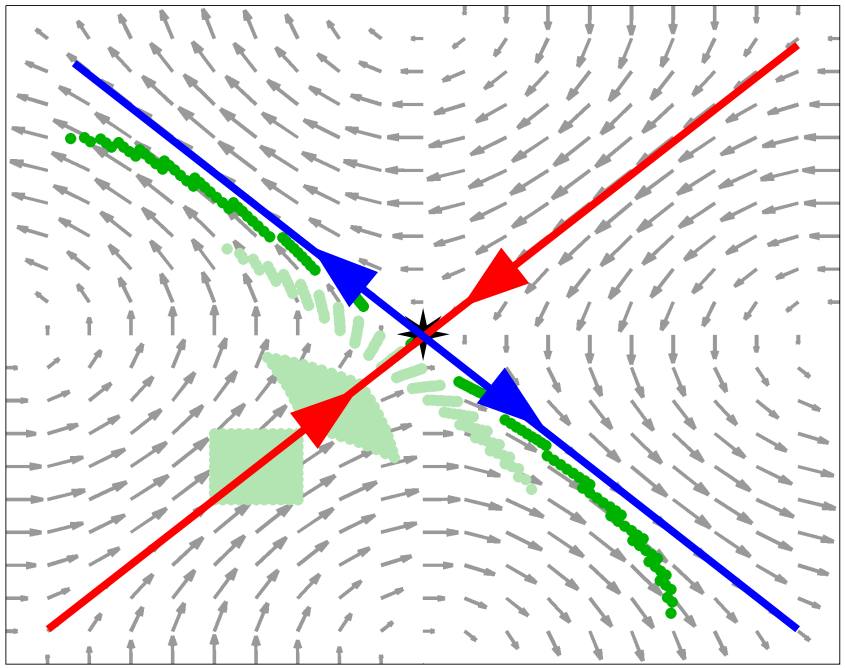
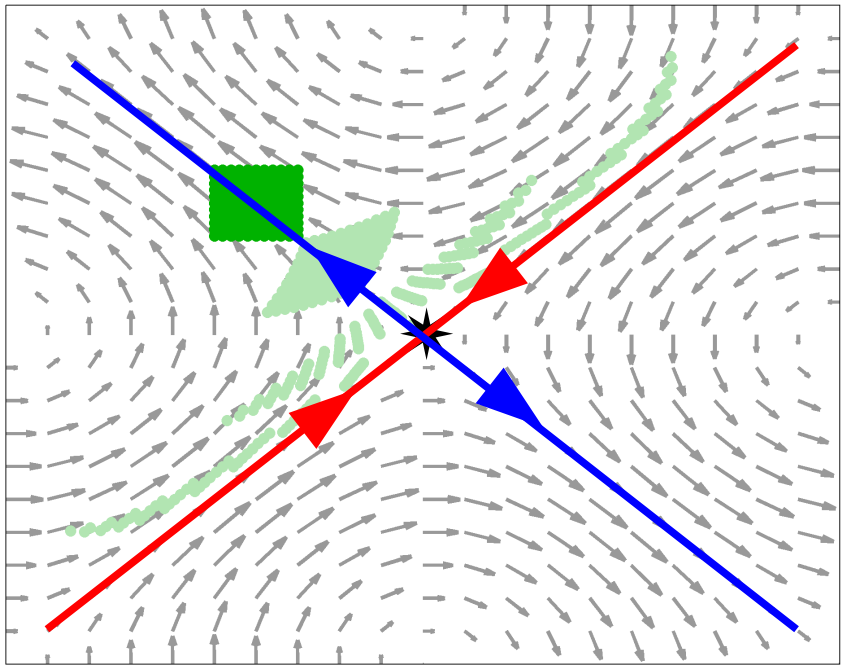
- Lagrangian Coherent Structures (LCSs) important diagnostic: identification of transport preferential directions and barriers
- Example: **Particle dispersion around an hyperbolic point**



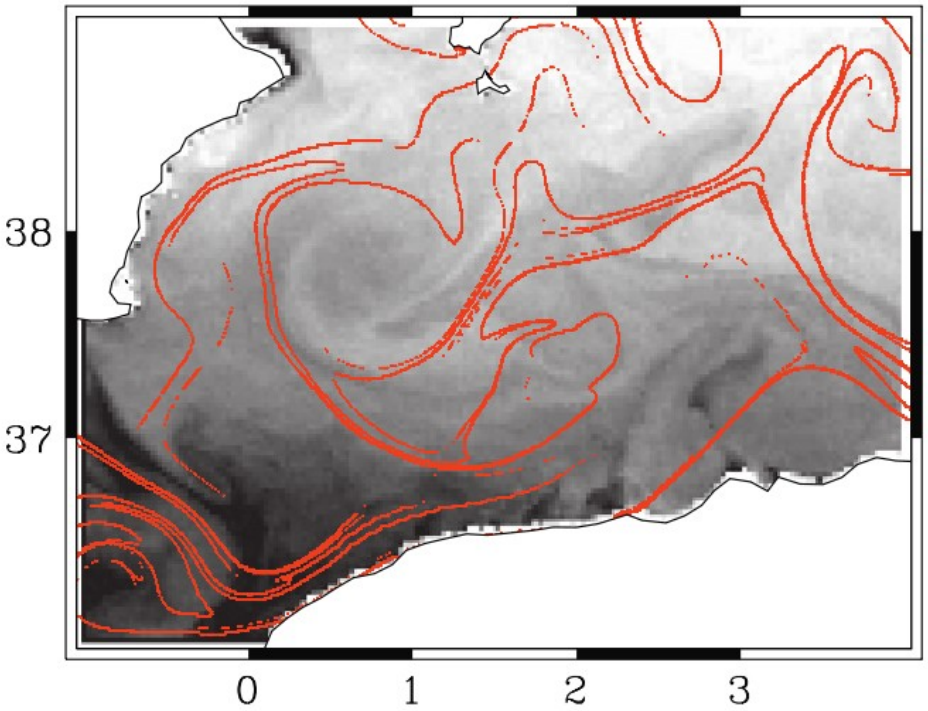


- Particles move along and spread across converging direction: **Repelling LCS**
- Particles align along diverging direction (transport barrier): **Attracting LCS**

Open ocean LCSs

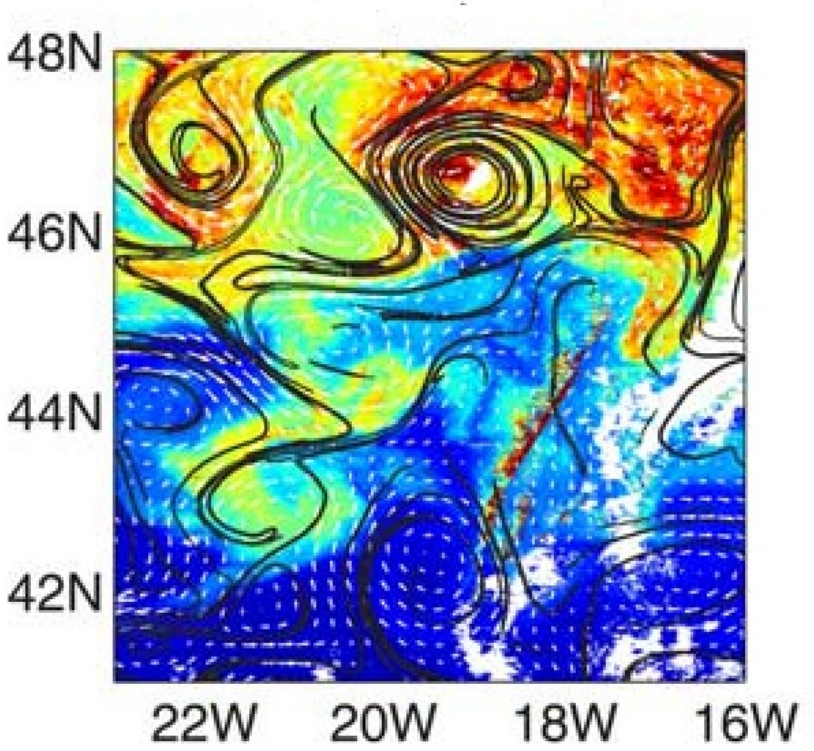
- Open ocean: **LCSs from altimetry velocity fields using Lyapunov Exponents**
- **Detected structures compared to advected tracers**

LCSs (red) and SST – SW Mediterranean



(*d'Ovidio et al., 2009*)

LCSs (black) and Chl – N Atlantic

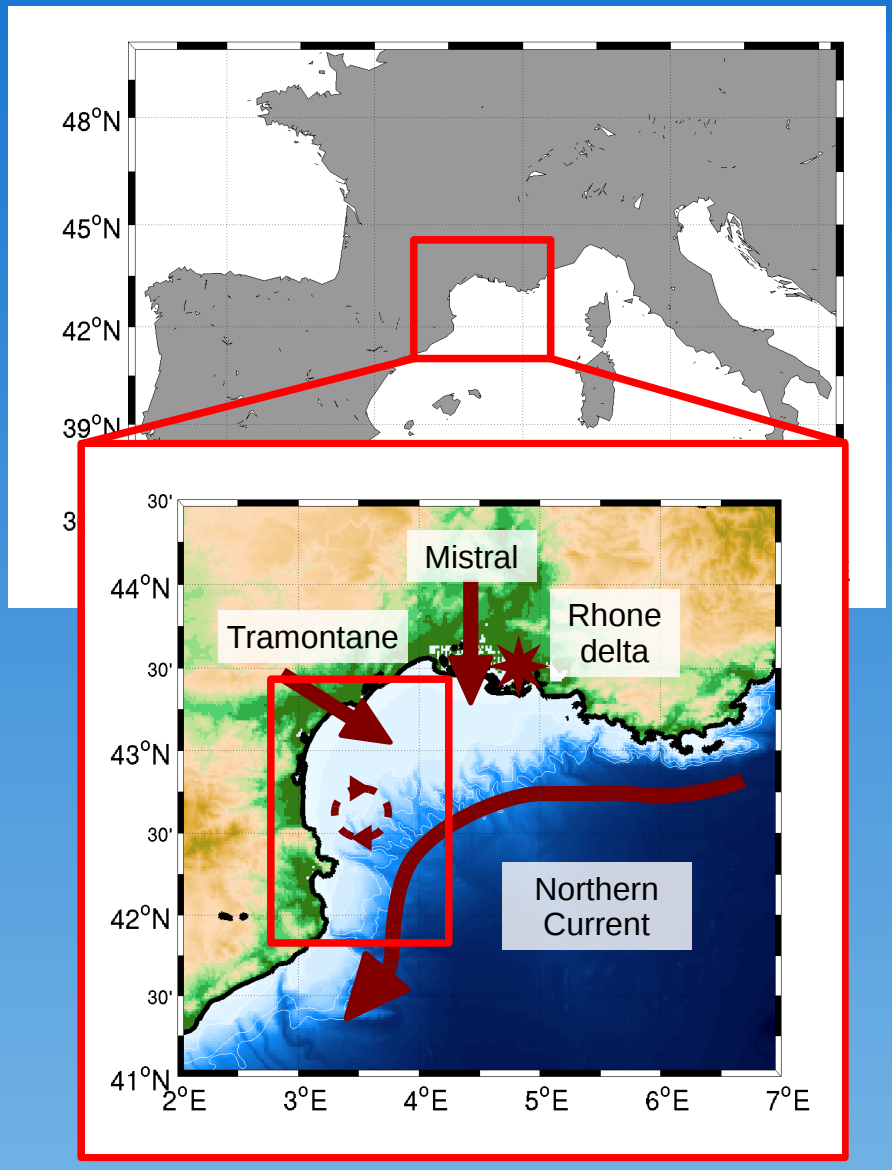


(*Lehahn et al., 2007*)

- **Accuracy still relatively untested in coastal areas**

The Gulf of Lion

- **Altimetry LCSs compared to *in-situ* LCSs in the Gulf of Lion (GoL)**



- **Large continental shelf**
- **Three main forcings:**
  - **Mistral & Tramontane**
  - **Delta of Rhone river**
  - **Northern Current**
- **NC dynamical barrier to cross-shelf exchanges**
- **(Sub)mesoscale anticyclones in the western part**

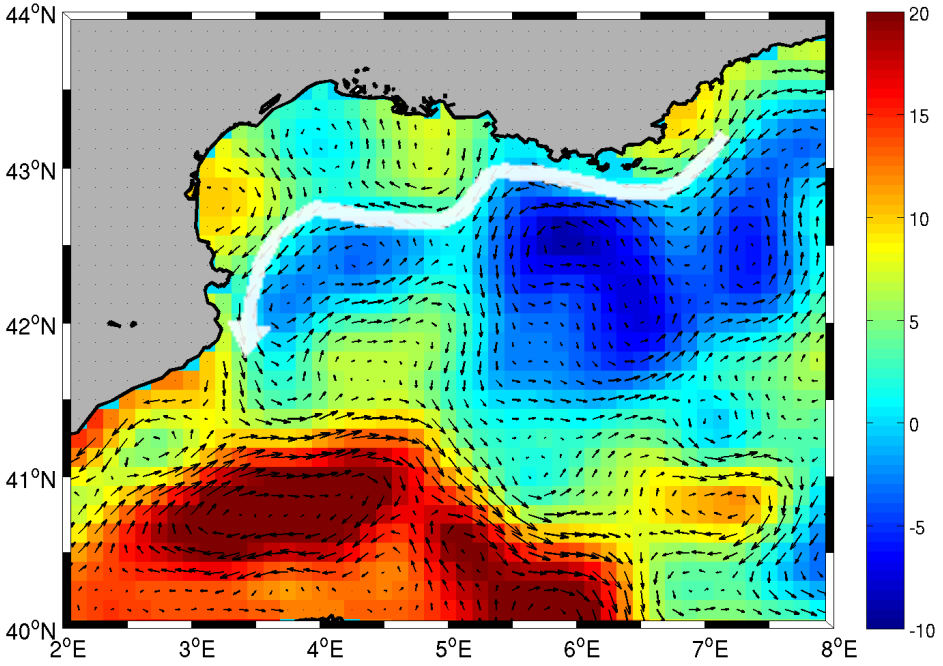
Lagrangian Transport Experiment
Latex10, September 1-24, 2010

Transport and biogeochemistry in the western part of the GoL

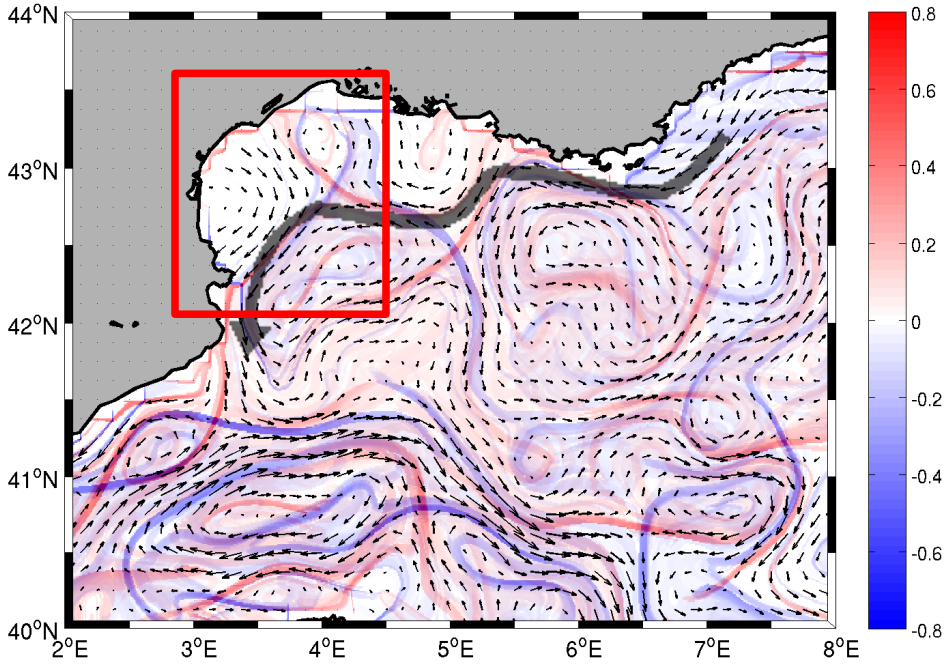
Altimetry LCSs

- **Altimetry LCSs from AVISO velocities using Finite-size Lyapunov exponents analysis (FSLE; *d'Ovidio et al., 2004*)**
- **Geostrophic surface velocity fields derived from SSH**
- **1/8 degree, daily**

AVISO SSH (shaded) & velocity vectors September 18, 2010



Attractive (blue) & Repulsive (red) LCSs from FSLE (day^{-1})



In-situ LCSs

Latex10 Adaptive Sampling Strategy for detection of *in-situ* LCSs:

1. Position of large scale LCSs estimated from altimetry derived FSLE
2. *In-situ* deployment of drifters
3. Mapping of *in-situ* velocities (hull mounted ADCP)

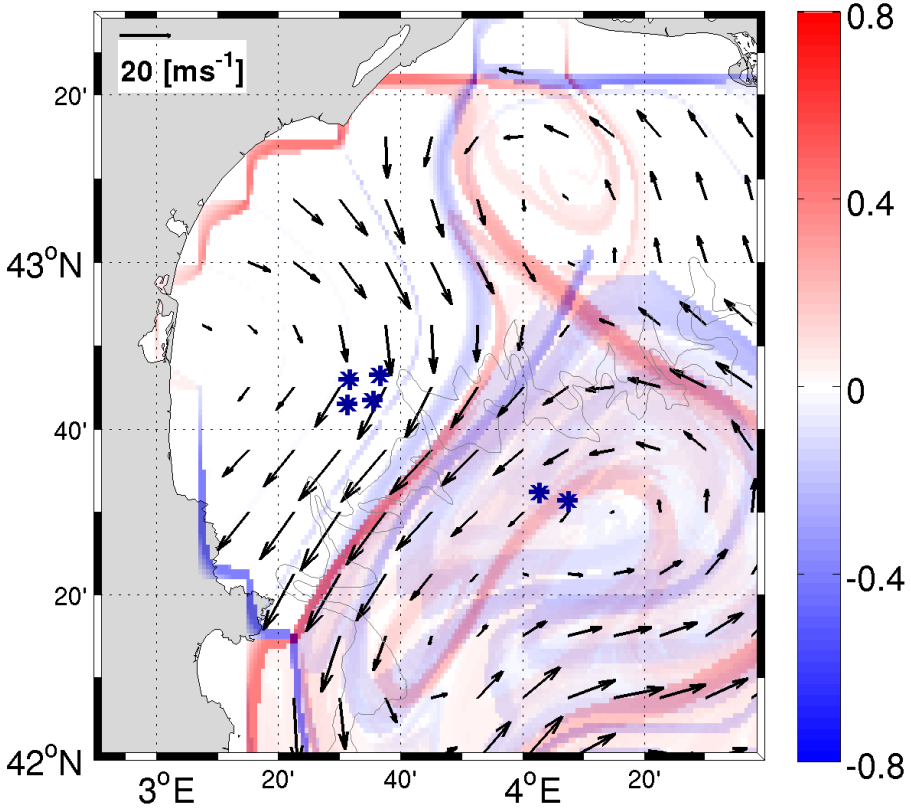
Deployment of 3 drifter arrays:

- ➔ Lyap01 (September 12)
- ➔ Lyap02 (September 18)
- ➔ Lyap03 (September 21)

Lyap01 – Sept 12 - 14

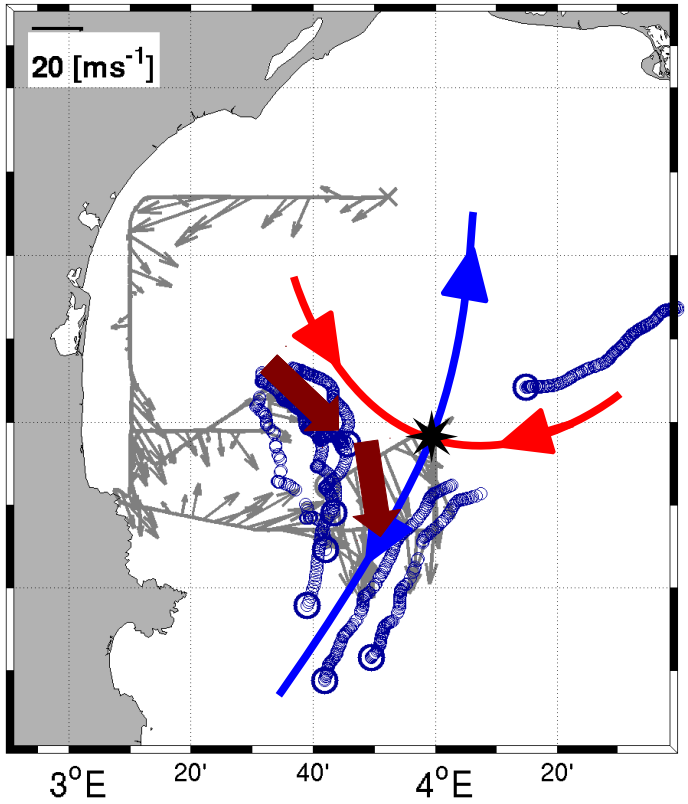
September 12, 2010

- Altimetry geostrophic velocity vectors
- Attractive (blue) & Repulsive (red) LCSs
- Initial position of drifter array



September 12-14, 2010

- Drifter trajectories
- *In-situ* LCSs
- 15m ADCP velocity vectors

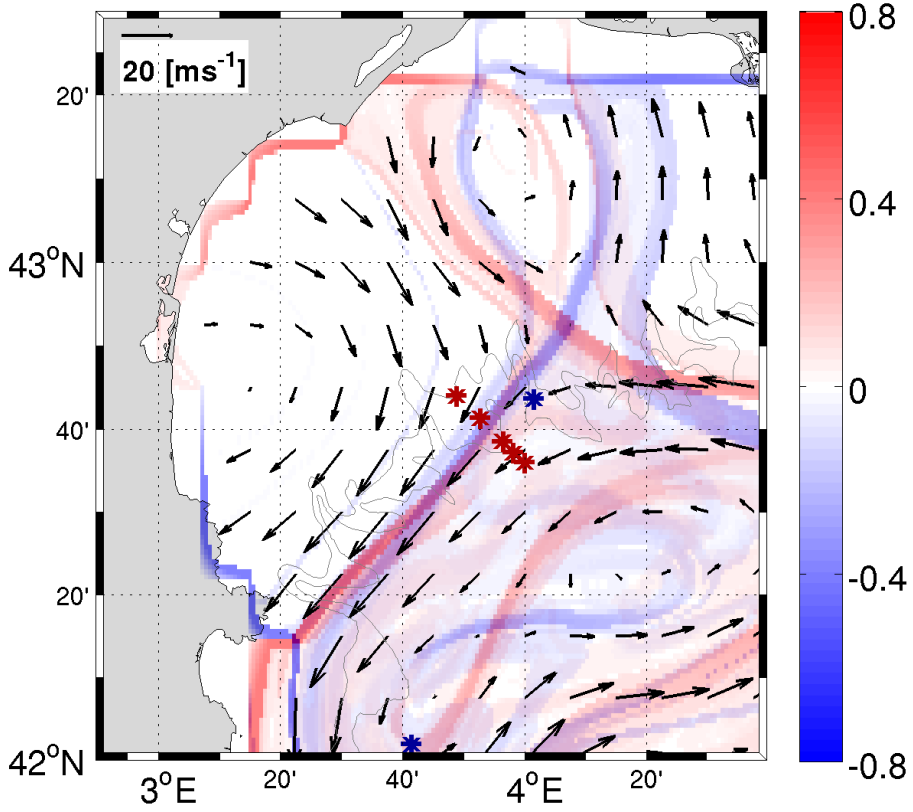


- **Repelling LCS on the continental shelf not detected**
- **Confirmed by ADCP velocities**

Lyap02 – Sept 18 - 20

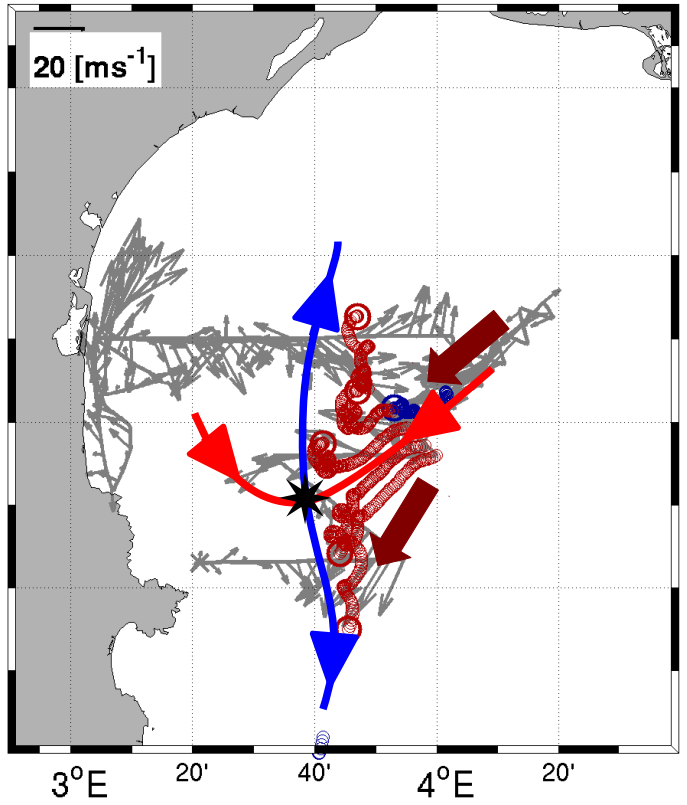
September 18, 2010

- Altimetry geostrophic velocity vectors
- Attractive (blue) & Repulsive (red) LCSs
- Initial position of drifter array



September 18-20, 2010

- Drifter trajectories
- *In-situ* LCSs
- 15m ADCP velocity vectors

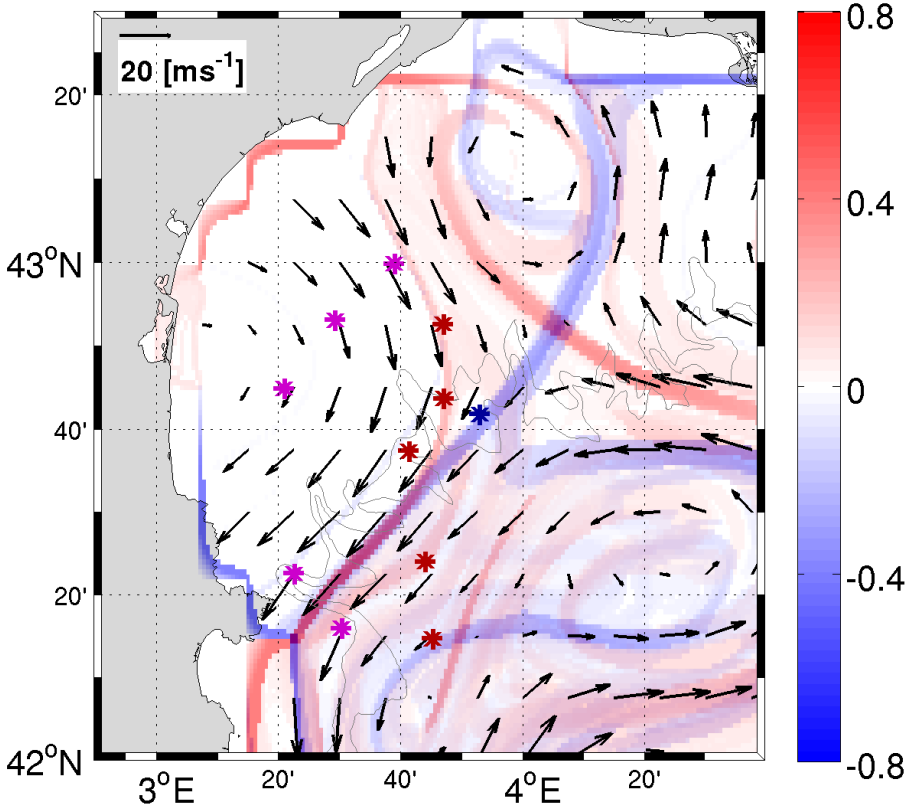


- Satellite structures similar to Sept. 12
- **Accurate identification of LCSs and hyperbolic point**

Lyap03 – Sept 21 - 24

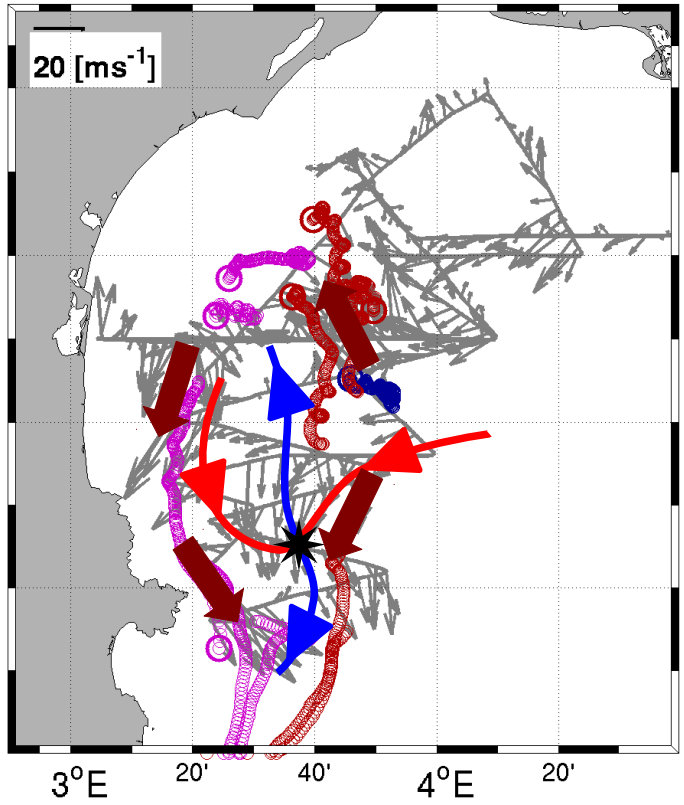
September 21, 2010

- Altimetry geostrophic velocity vectors
- Attractive (blue) & Repulsive (red) LCSs
- Initial position of drifter array



September 21-24, 2010

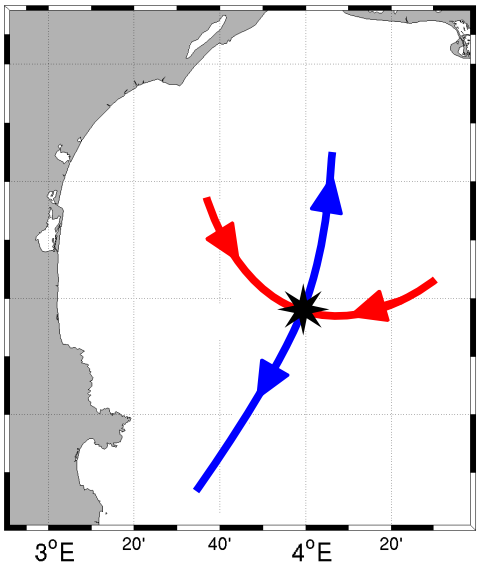
- Drifter trajectories
- *In-situ* LCSs
- 15m ADCP velocity vectors



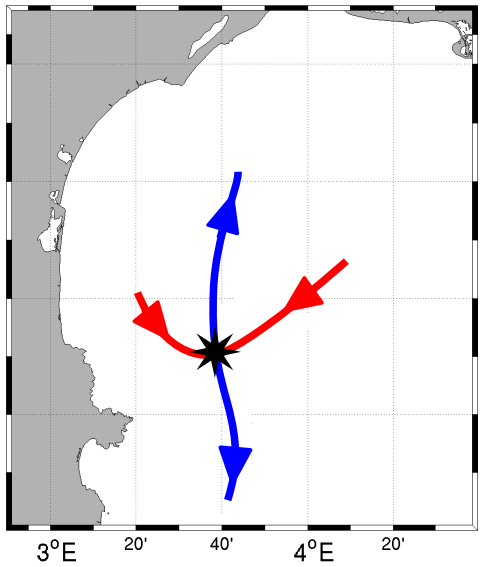
- Satellite structures similar to Sept. 12
- Cyclonic circulation on the continental shelf
- ADCP indicate presence of southward coastal jet

Hyperbolic point migration

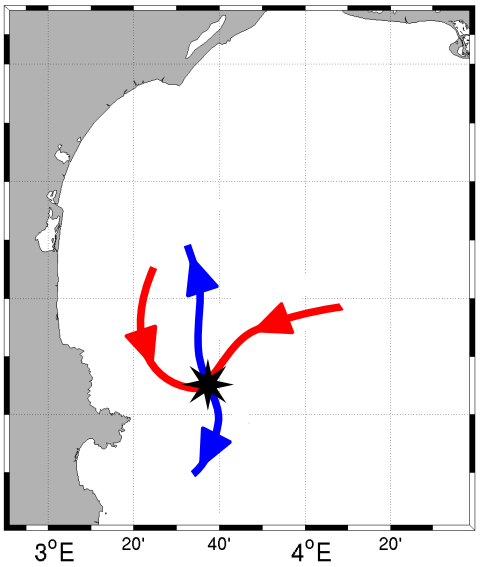
Lyap01



Lyap02



Lyap03

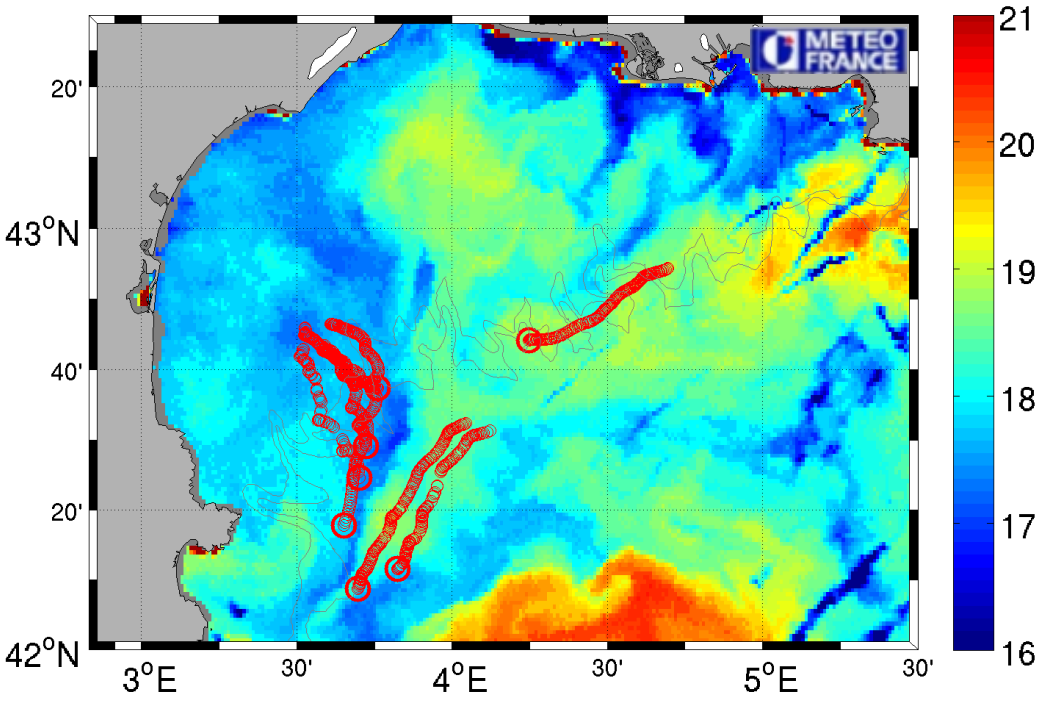


- **In-situ LCSs tracked for two weeks (September 12-24)**
- **Hyperbolic point translational speed ~ 5 cm sec^{-1}**
- **Slower than advection speed: satisfied basic condition for FSLE analysis!!!**

LCSs and satellite imagery

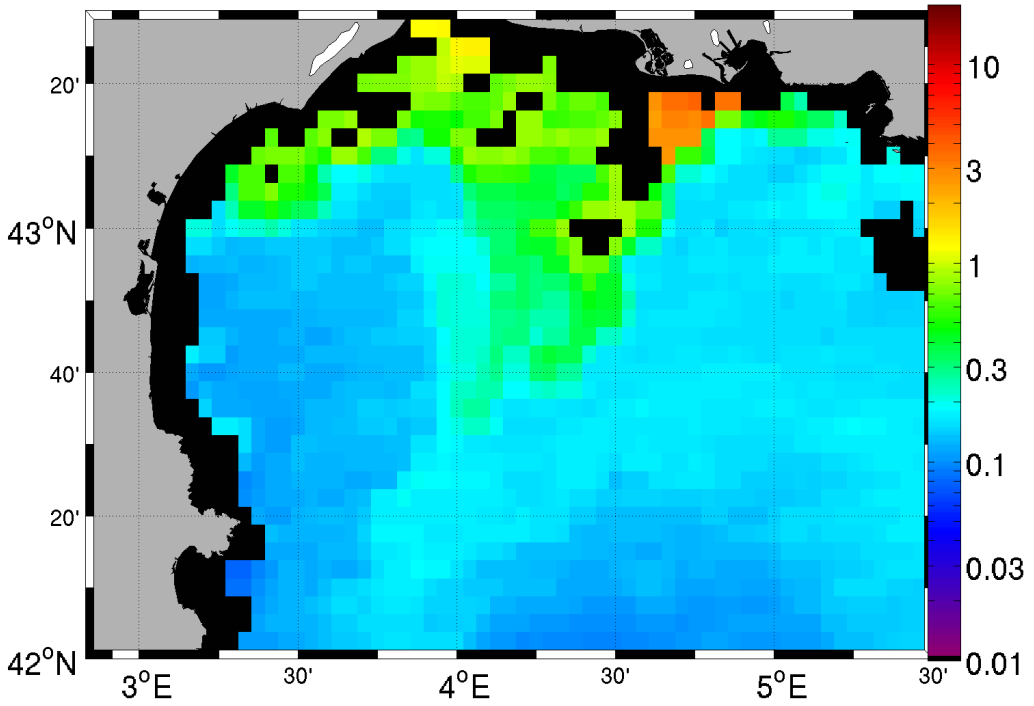
September 14, 2010

- AVHRR SST field
- Lyap01 drifter trajectories



September 14, 2010

- MODIS Chlorophyll concentrations (4 km resolution)



- In-situ LCSs associated with a front (NC and coastal waters)
- They identify coastal corridor along which water exit the GoL
- Importance of those structures to study cross-shelf exchanges
- Importance of those exchanges for biogeochemistry

Conclusions

- **Adaptive sampling strategy allowed to detect and track *in-situ* LCSs for two weeks**
- **Translational speed of hyperbolic point satisfies assumption for FSLE analysis**
- **LCSs identified a corridor along which coastal waters left the continental shelf of the GoL**
- **Altimetry LCSs showed some limitations in the coastal region**
- **Corrections are required to improve coastal transport analysis from altimetry velocity fields**

Future Work

- **Quantification of transport**
- **Improve satellite velocity field:**
  - → Different processing schemes for raw data
  - → Add ageostrophic components (Ekman, NIO...)
  - → HF Radar velocities
- **Numerical models:**
  - → Extend transport analysis to the whole GoL
  - → Test corrections
- **Analysis of previous Latex datasets**
- **Further Lyap experiments (???)**

<u>Final goal</u>

Method for estimate & predict coastal transport/exchanges (pollutants, oil spill, larval/jellyfish transport, fisheries)

References

F. Nencioli, F. d'Ovidio, A. Doglioli, A. Petrenko
Surface coastal circulation patterns by in-situ detection of Lagrangian Coherent Structures
(*to be submitted*)

More on LATEX at EGU2011:

- Biogeochemical modeling, Campbell, **OS3.2, Wed. 11:00**
- Lagrangian Tools, Doglioli, **OS2.1, Poster XY 597**
- Transport and biogeochemistry, Nencioli, **OS3.2, Poster XY 599**
- Anticyclones generation, Petrenko, **OS2.1, Poster XY 624**

LATEX website:
www.com.univ-mrs.fr/LOPB/LATEX

Acknowledgments
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