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

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LOPB

*EGU General Assembly 2011*
**April 8, 2011, Vienna**

# Lagrangian Coherent Structures

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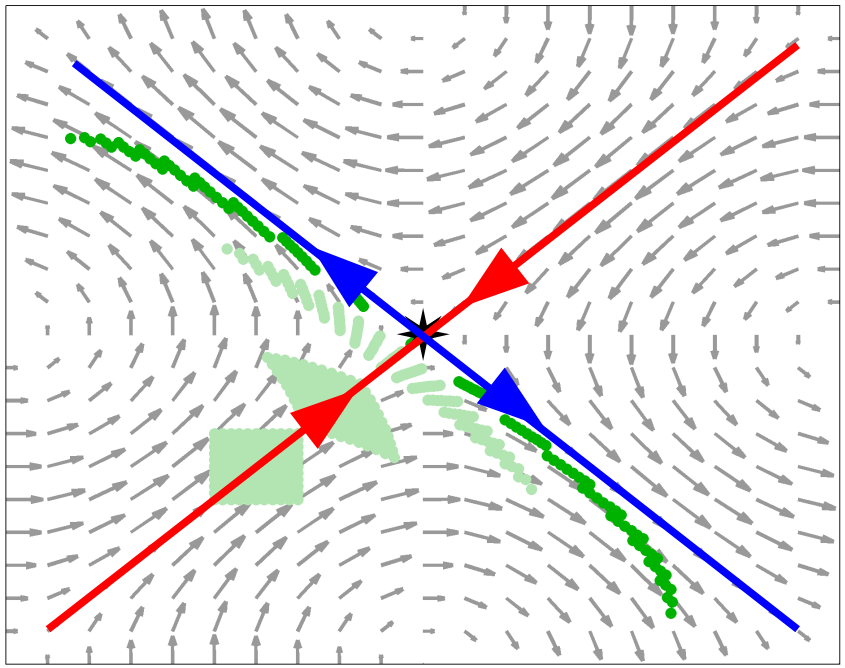
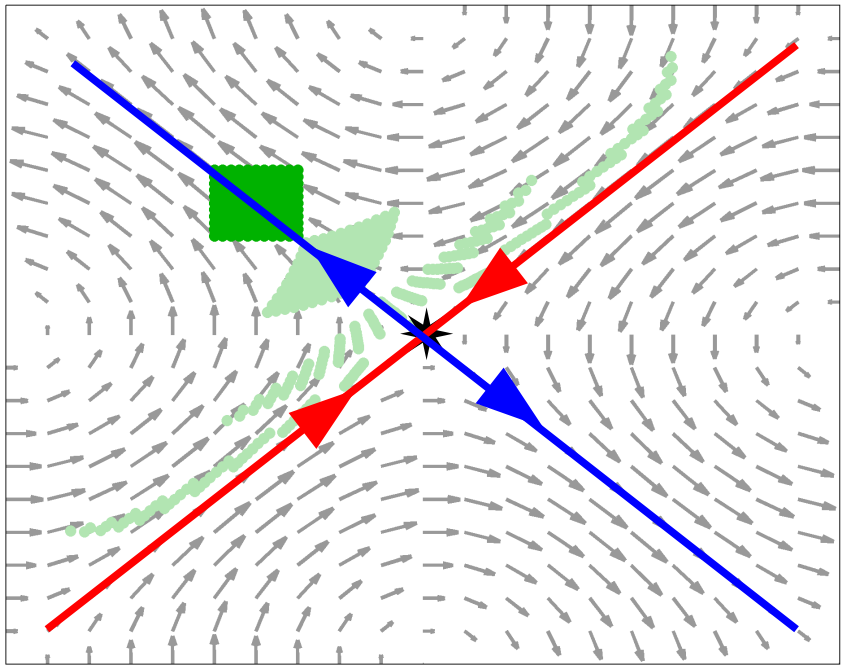
- Lagrangian Coherent Structures (LCSs) important diagnostic: identification of transport preferential directions and barriers
- Example: **Particle dispersion around an hyperbolic point**





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

# Open ocean LCSs

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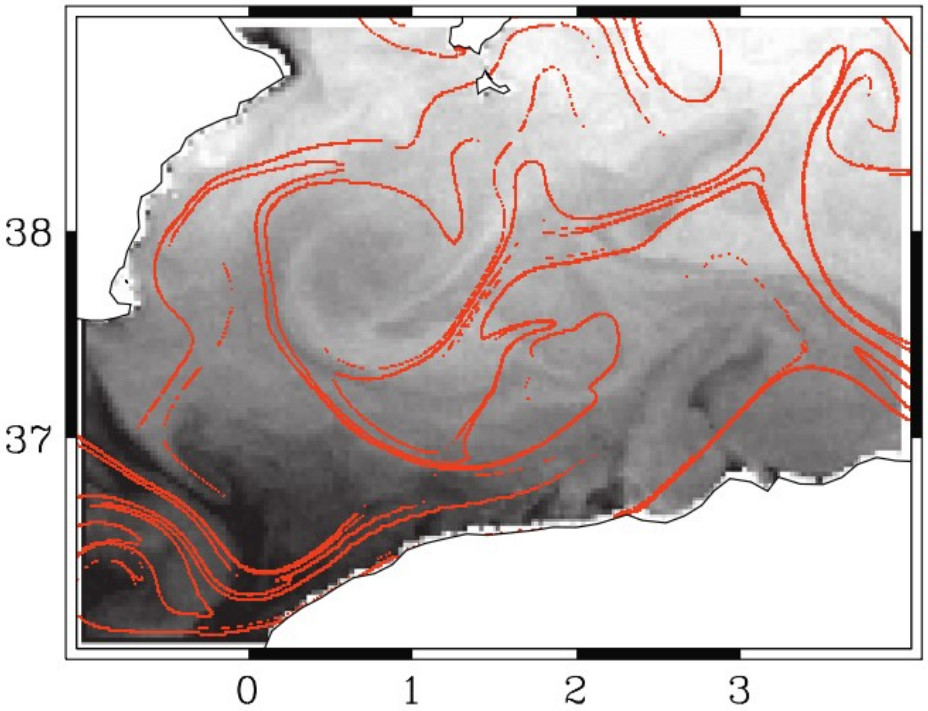
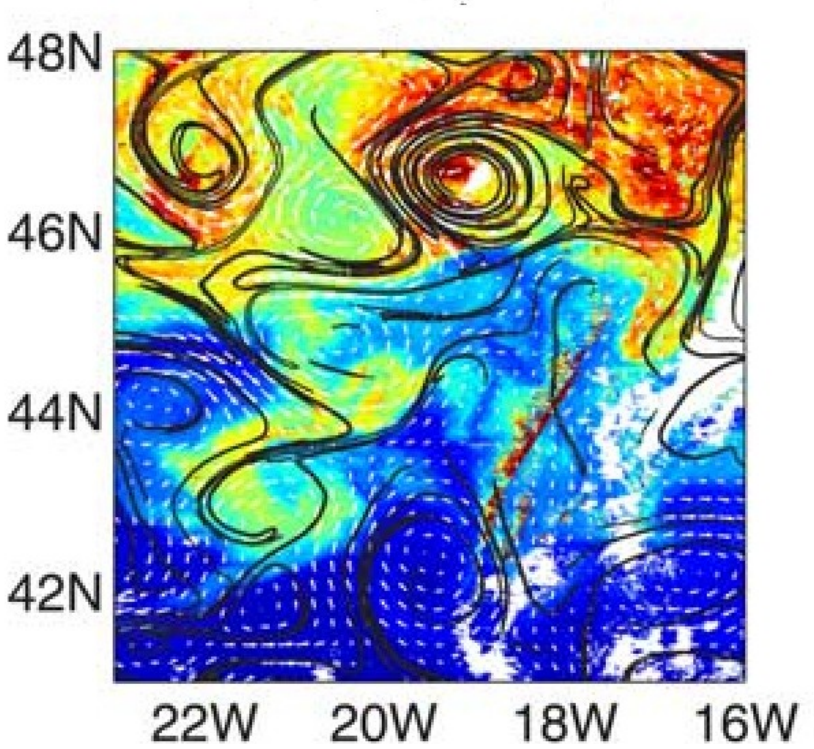
- Open ocean: **LCSs from altimetry velocity fields using Lyapunov Exponents**
- **Detected structures compared to advected tracers**

**LCSs (red) and SST – SW Mediterranean**




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

**LCSs (black) and Chl – N Atlantic**

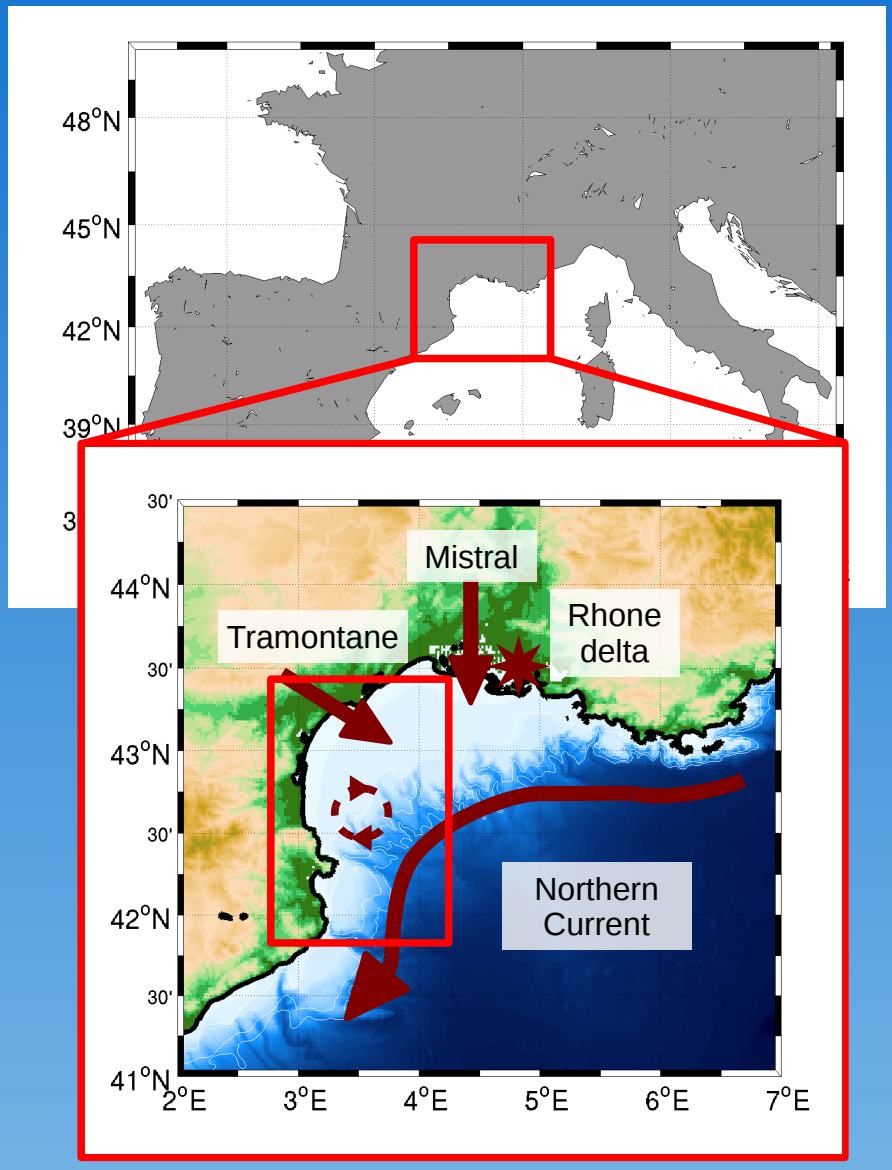



(*Lehahn et al., 2007*)

- **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

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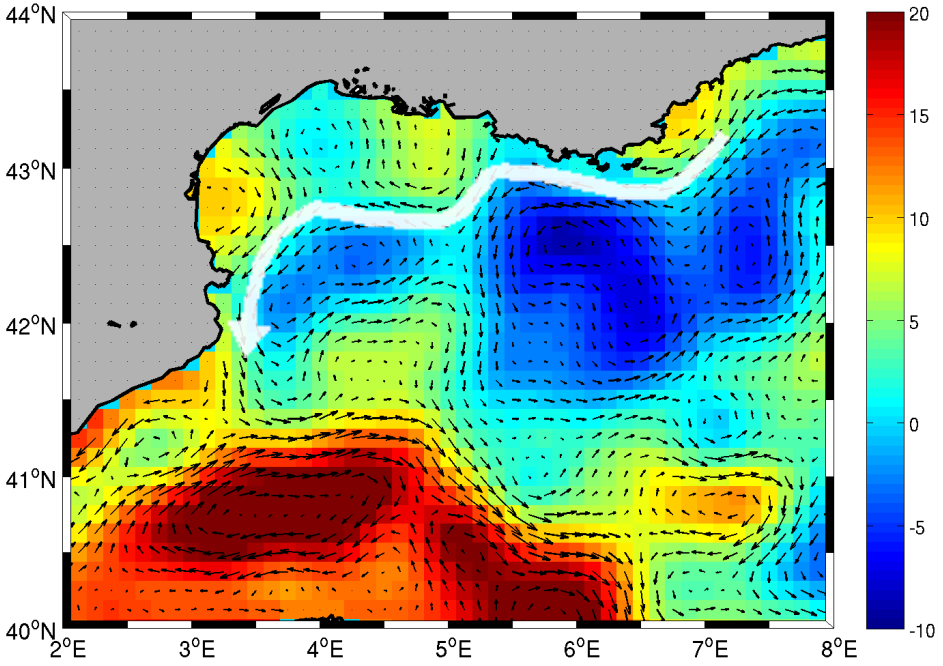
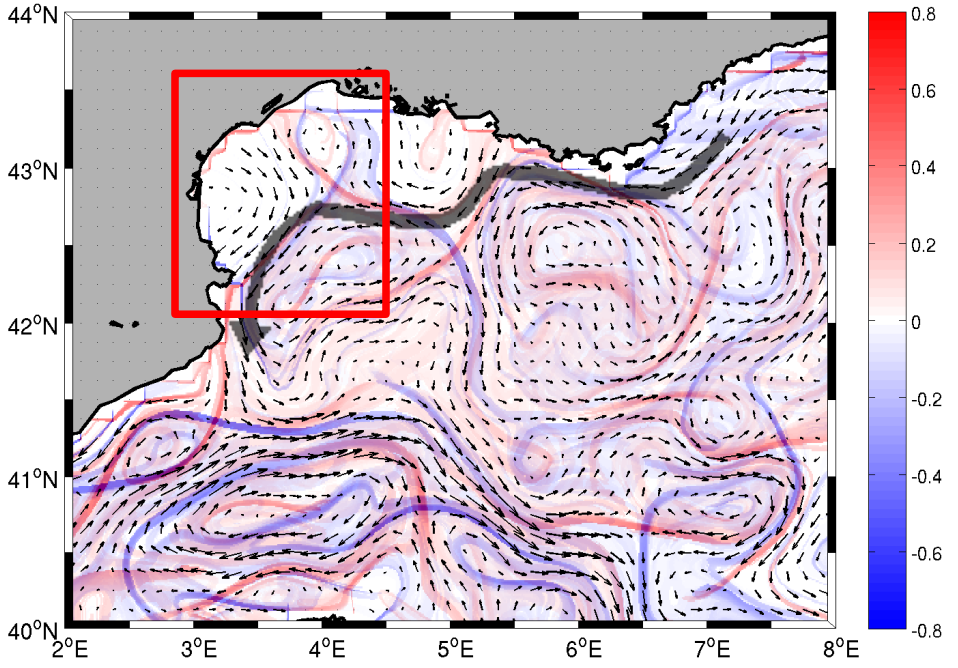
- **Altimetry LCSs from AVISO velocities using Finite-size Lyapunov exponents analysis (FSLE; *d'Ovidio et al., 2004*)**
- **Geostrophic surface velocity fields derived from SSH**
- **1/8 degree, daily**

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




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



# In-situ LCSs

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## 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

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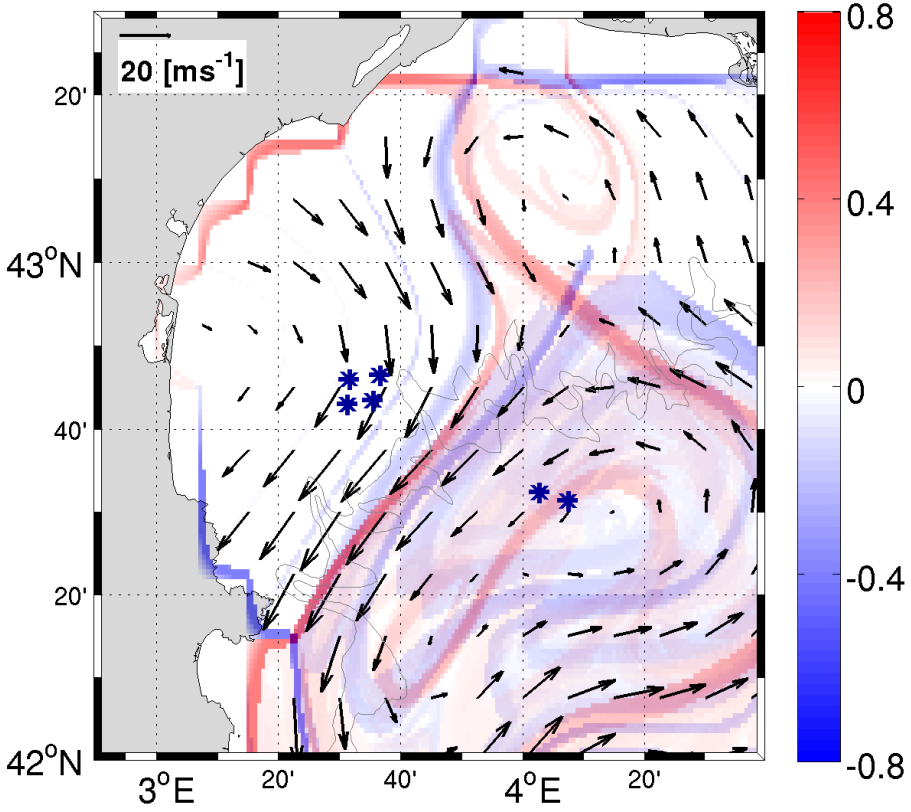
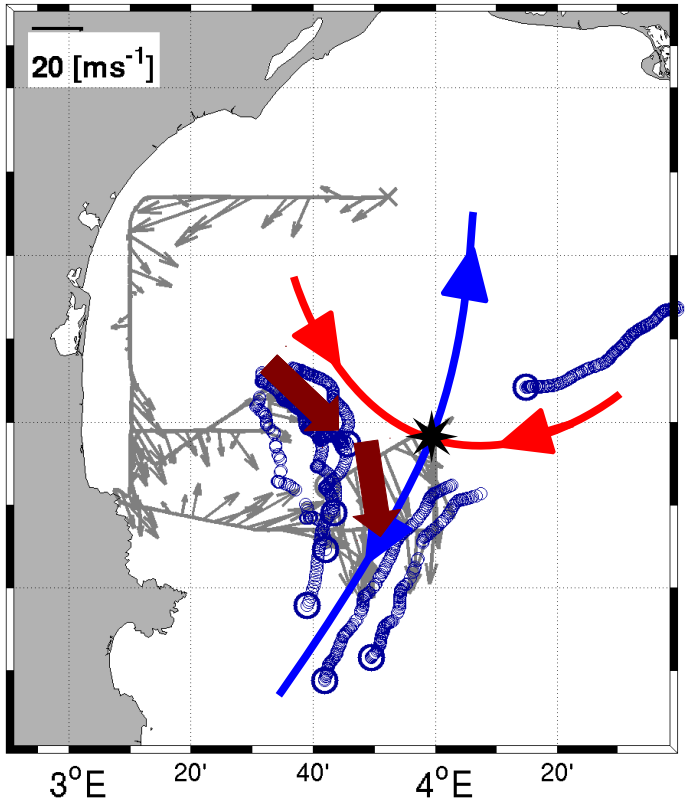
## September 12, 2010

- 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

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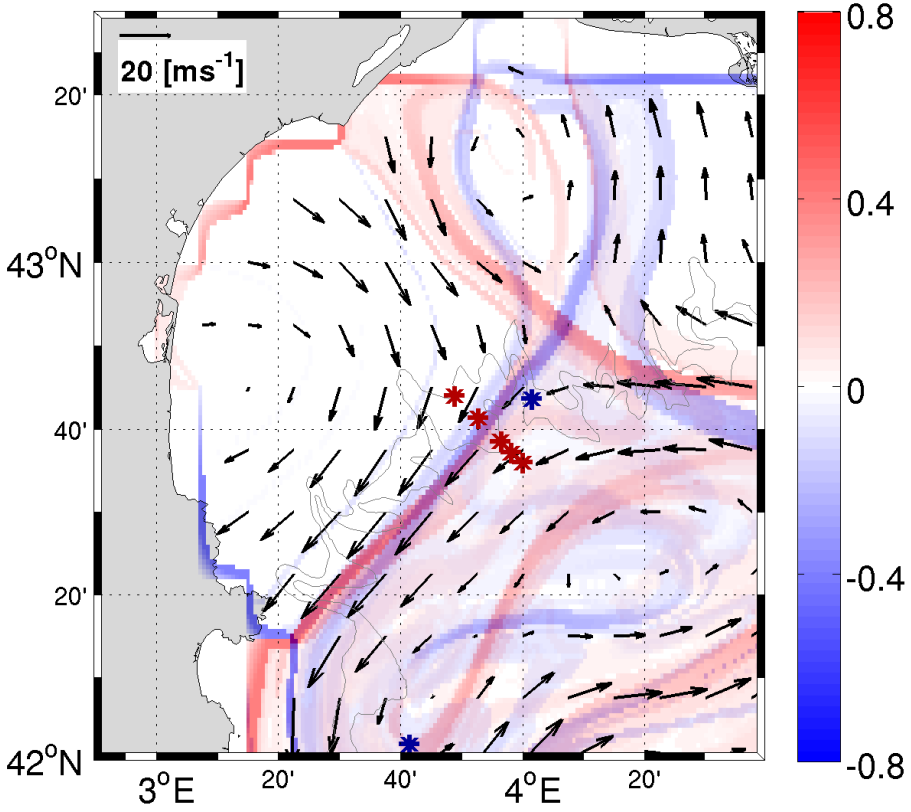
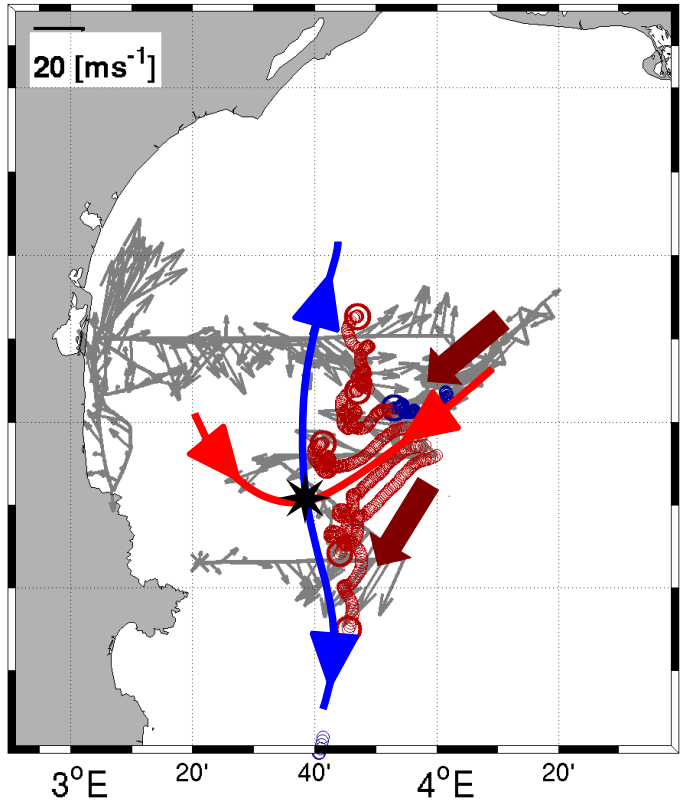
## September 18, 2010

- 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

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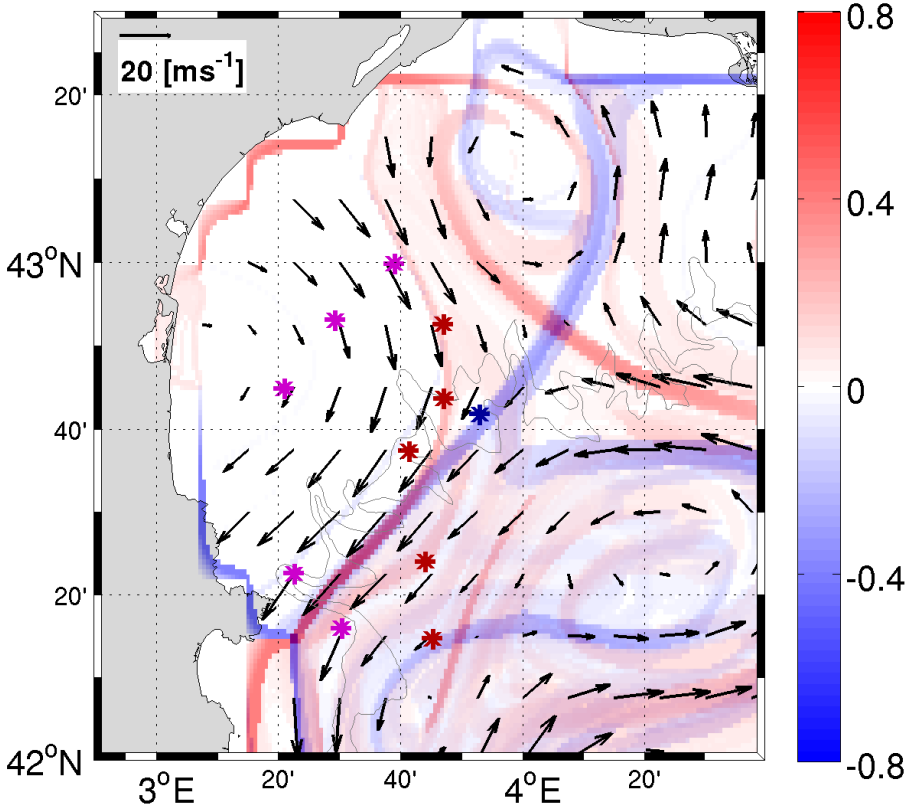
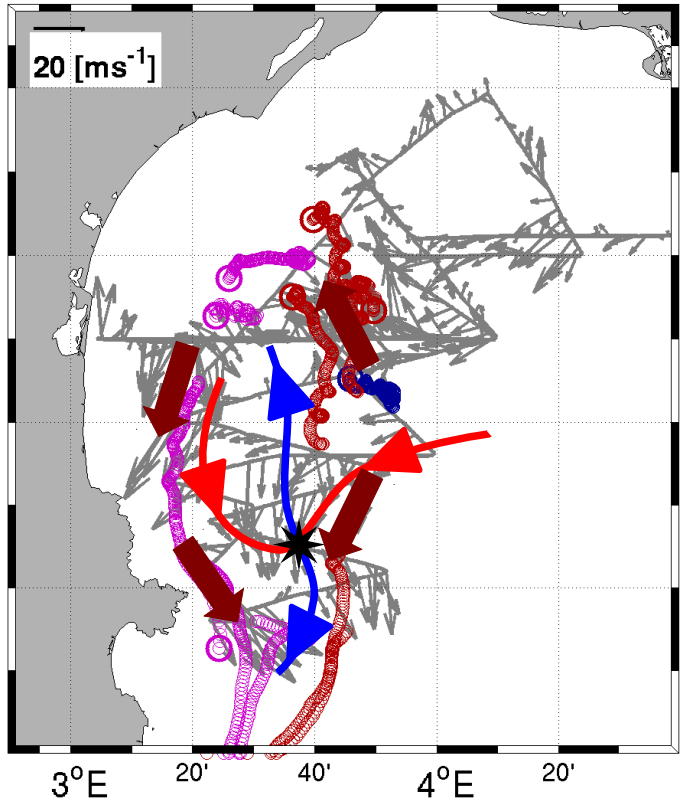
## September 21, 2010

- 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

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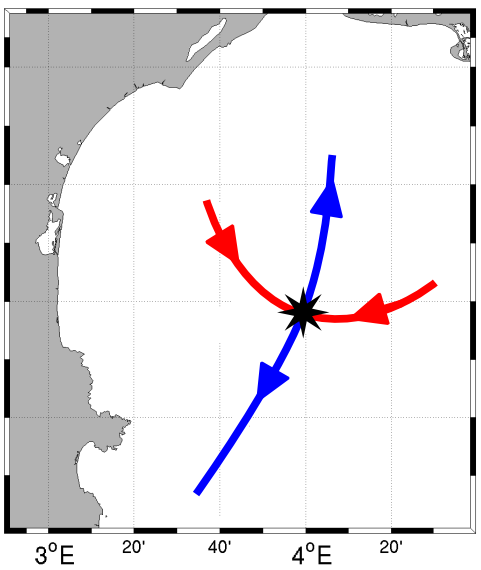
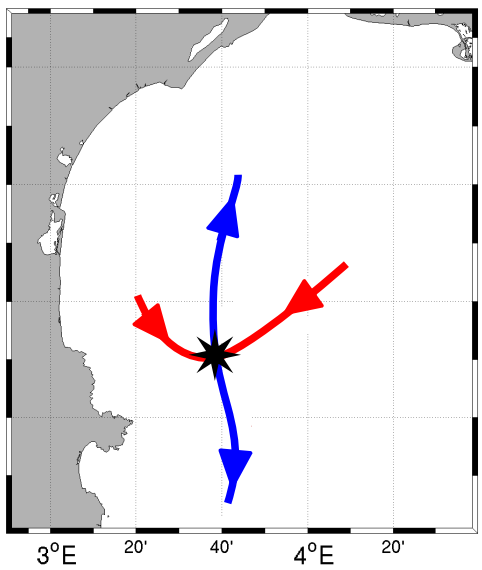
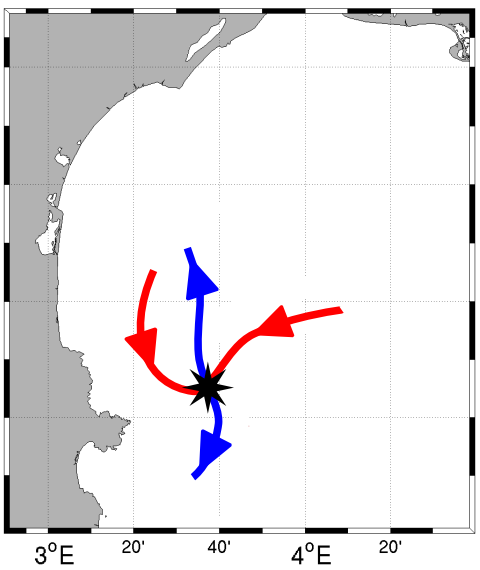
**Lyap01**




**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

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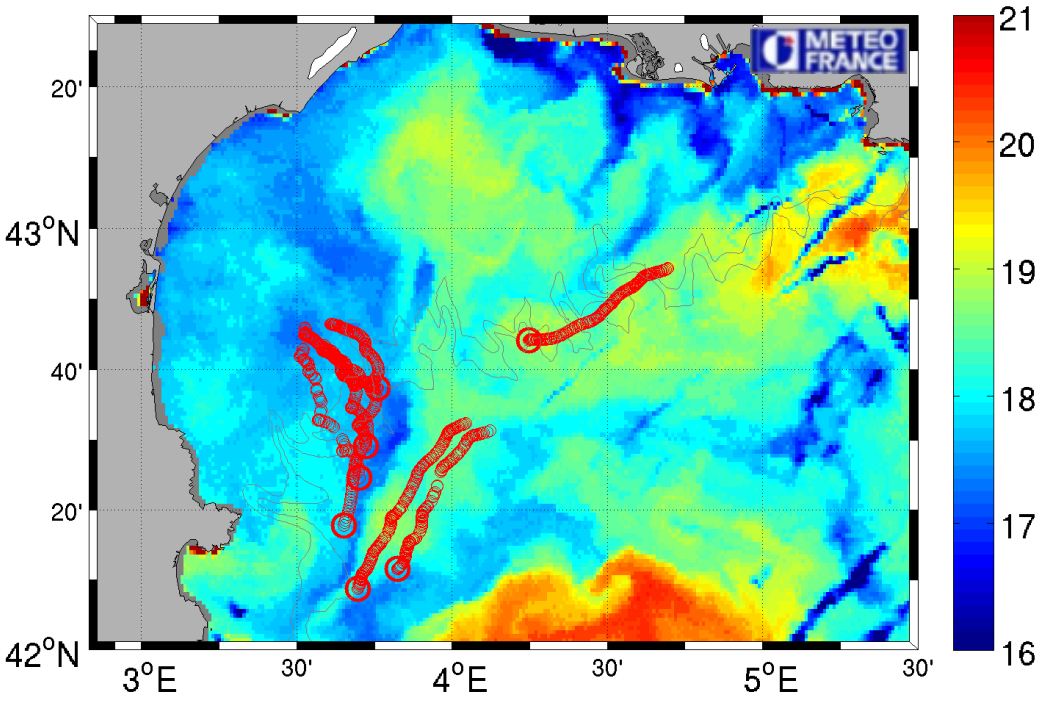
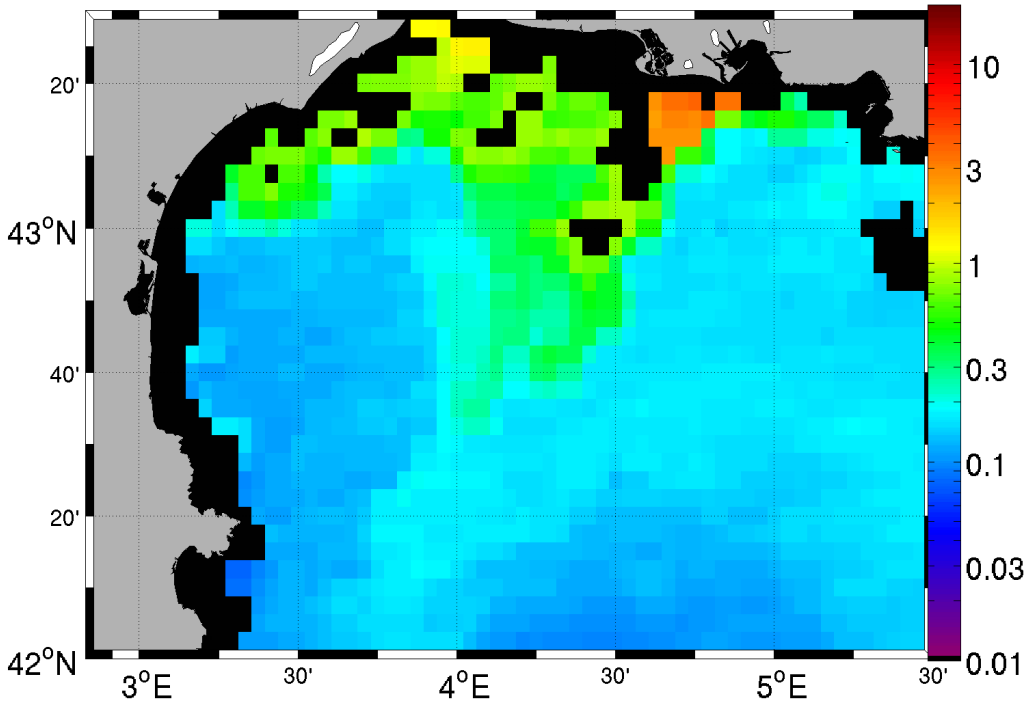
## September 14, 2010

- 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

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- 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

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- 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**
Special thanks to the leading PI's and the all the participants of the LATEX project. Thanks to the crew of the RV Téthys II for their help at sea during the Latex10 experiment. Météo-France provided AVHRR satellite imagery. The LATEX project is supported by the programs LEFE/IDAO and LEFE/CYBER of INSU-Institut National de Sciences de l'Univers and by the Region PACA-Provence Alpes Côte d'Azur.