

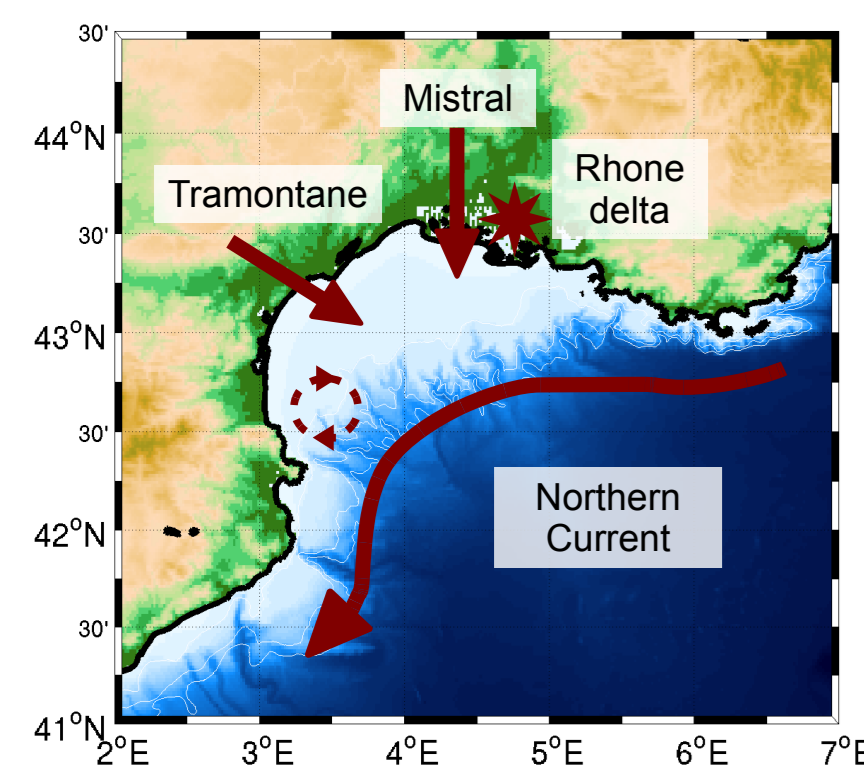
A multi-platform approach to investigate submesoscale structures in a coastal region and their impacts in regulating cross-shelf exchanges

Francesco Nencioli⁽¹⁾, Anne A. Petrenko⁽¹⁾, Andrea M. Doglioli⁽¹⁾, Francesco d'Ovidio⁽²⁾, Pierre Testor⁽²⁾, Marion Kersalé⁽¹⁾ and Jérôme Bouffard⁽¹⁾

⁽¹⁾ Aix-Marseille Univ., Mediterranean Institute of Oceanography, CNRS/INSU UMR 7294, IRD UMR 235, Marseille, France

⁽²⁾ Laboratoire d'Océanographie et du Climat : Experimentation et Approches Numeriques, IPSL, Paris, France

Introduction : The Gulf of Lion (North-western Mediterranean)

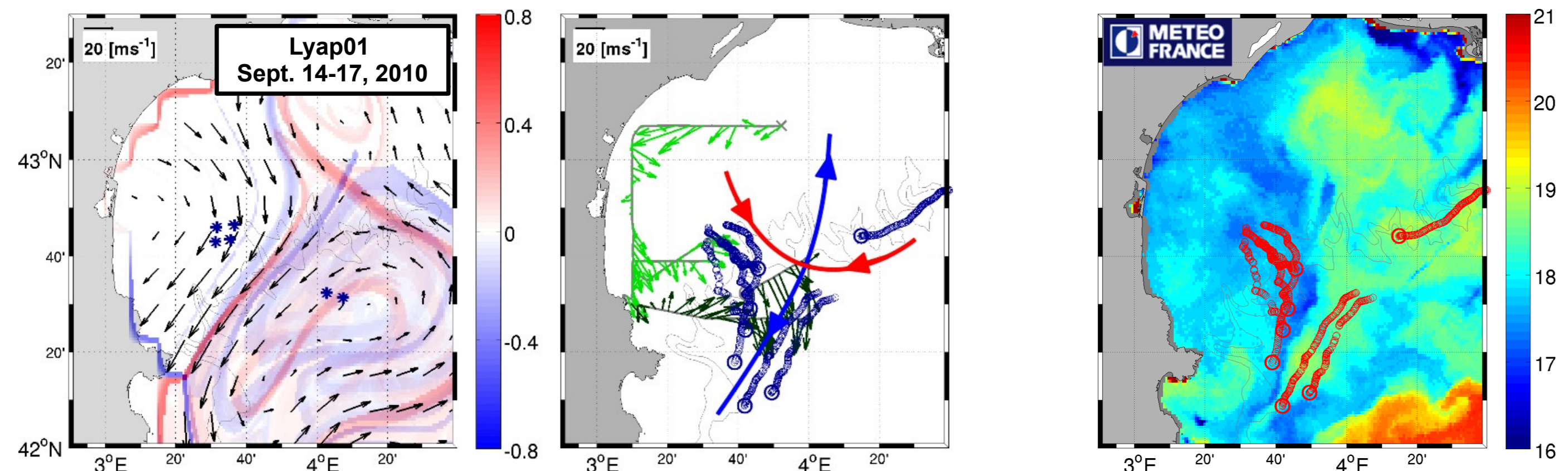


- The circulation is forced by three main factors: Northern Current – Mistral & Tramontane – Rhone
- The Northern Current (NC) acts as dynamical barrier between the Gulf of Lion (GoL) and the Mediterranean basin.
- Cross-shelf exchanges are affected by intrusions of the NC and (sub)mesoscale anticyclones in the western part of the basin.

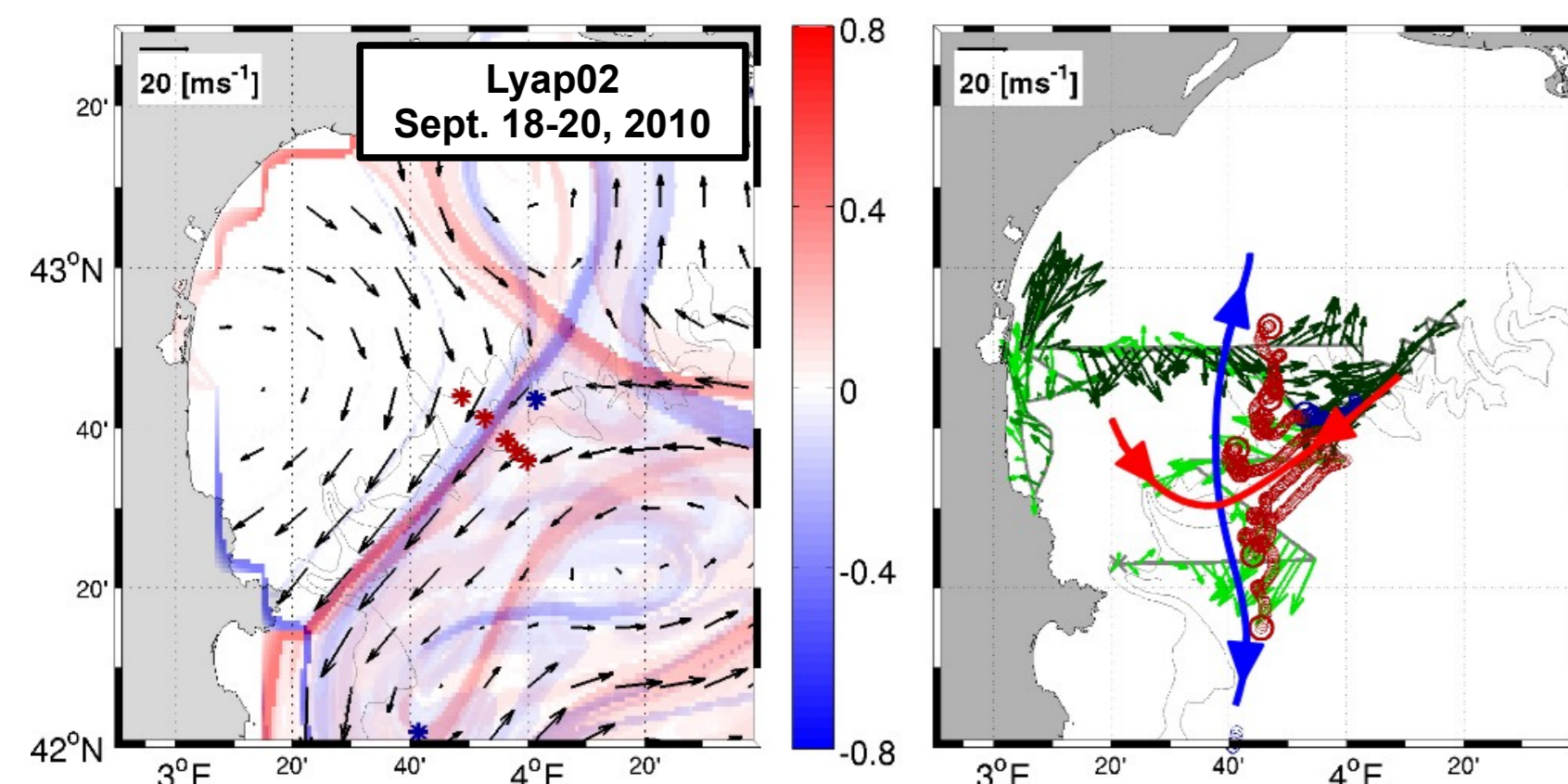
In the framework of the LATEX (Lagrangian Transport Experiment) project, the influence of these structures on horizontal transport and cross-shelf exchanges have been investigated using a multidisciplinary approach.

In-situ Detection of Lagrangian Coherent Structures

- LCSs are an important diagnostic to characterize horizontal advection of oceans flows as they identify preferential directions and transport barriers.

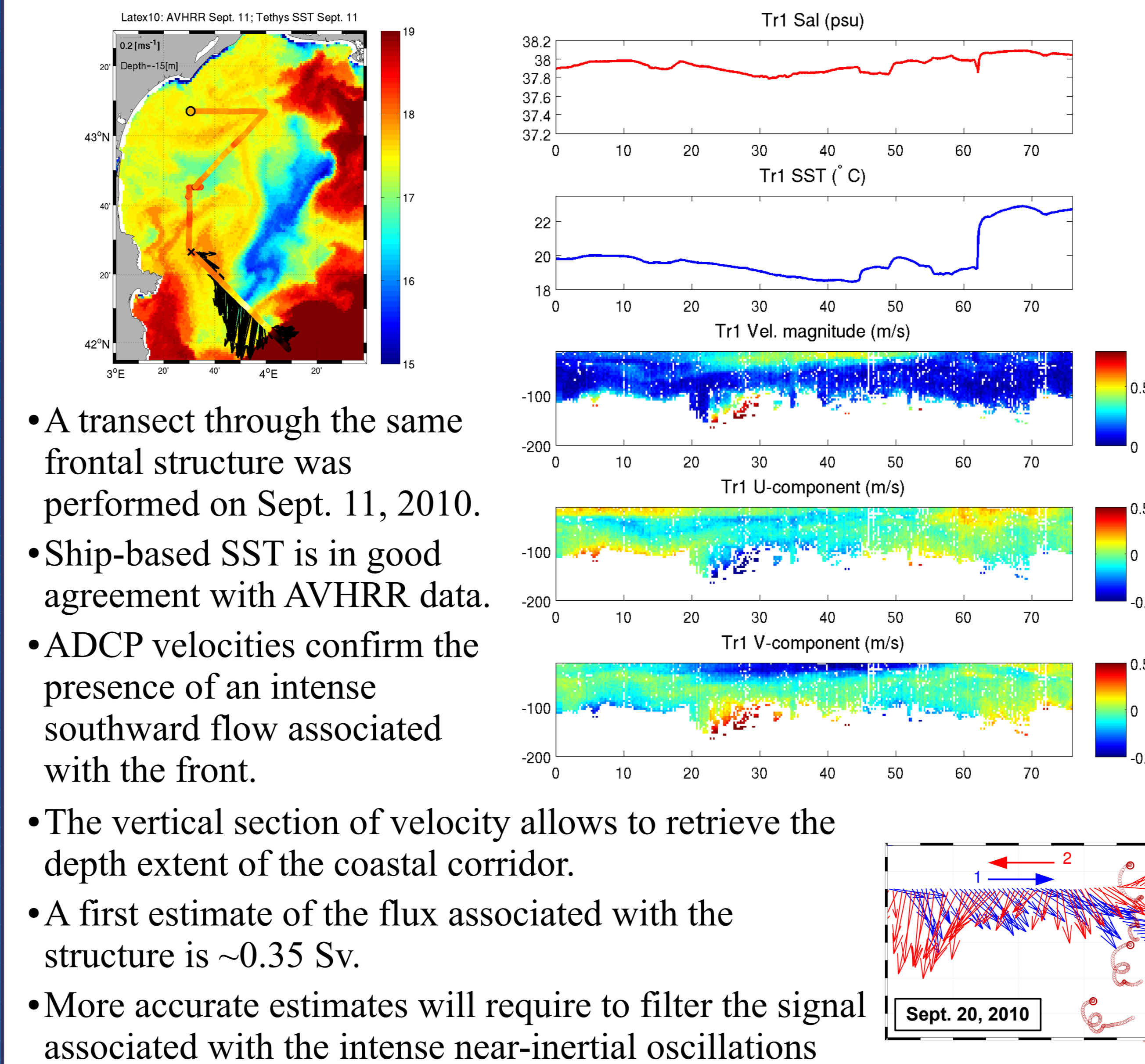


- LCSs were identified from AVISO velocities using Finite-Size Lyapunov Exponents (FSLE; d'Ovidio et al., 2004).
- Their accuracy was tested during the **Latex10 field experiment** (Sept. 1-24, 2010).
- An adaptive sampling strategy which combined satellite data, Lagrangian drifter releases and ship-based ADCP measurements allowed to localize *in-situ* LCSs (Nencioli et al., 2011).
- These evidenced some limitations of satellite derived LCSs over the continental shelf.



- AVHRR SST supports the *in-situ* detected LCSs.
- The structures were associated with a strong frontal region.
- They identified a coastal corridor along which colder coastal waters left the continental shelf.
- MODIS chlorophyll indicates important biogeochemical impact of these structures

Ship-based Observations

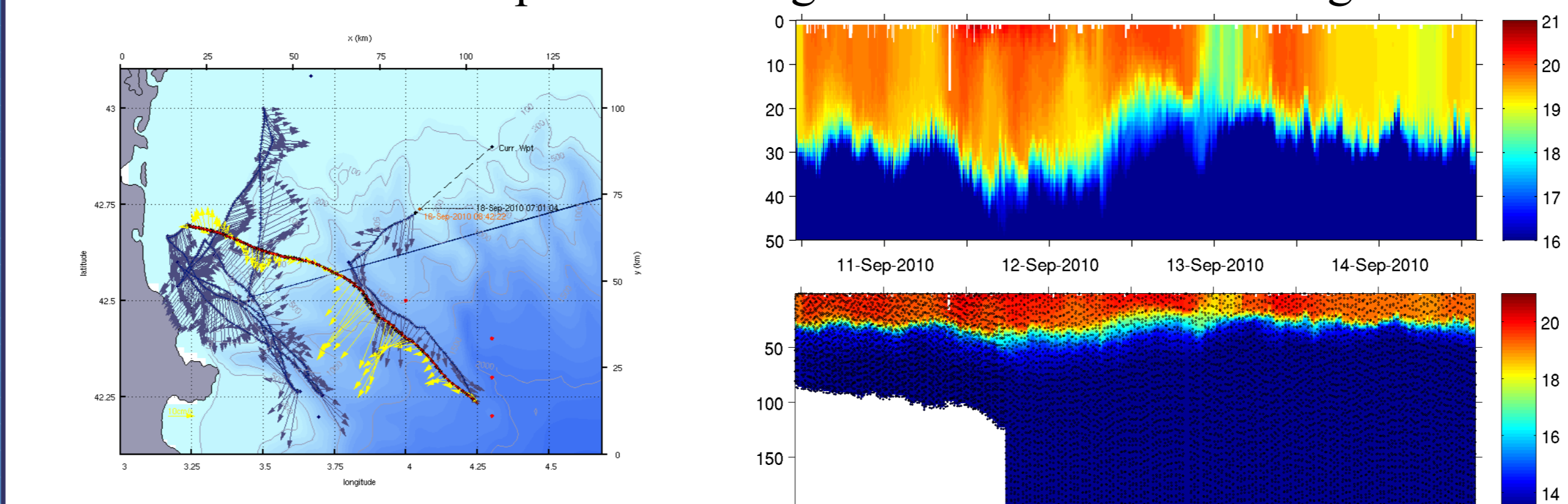


- A transect through the same frontal structure was performed on Sept. 11, 2010.
- Ship-based SST is in good agreement with AVHRR data.
- ADCP velocities confirm the presence of an intense southward flow associated with the front.
- The vertical section of velocity allows to retrieve the depth extent of the coastal corridor.
- A first estimate of the flux associated with the structure is ~ 0.35 Sv.
- More accurate estimates will require to filter the signal associated with the intense near-inertial oscillations

Glider Observations



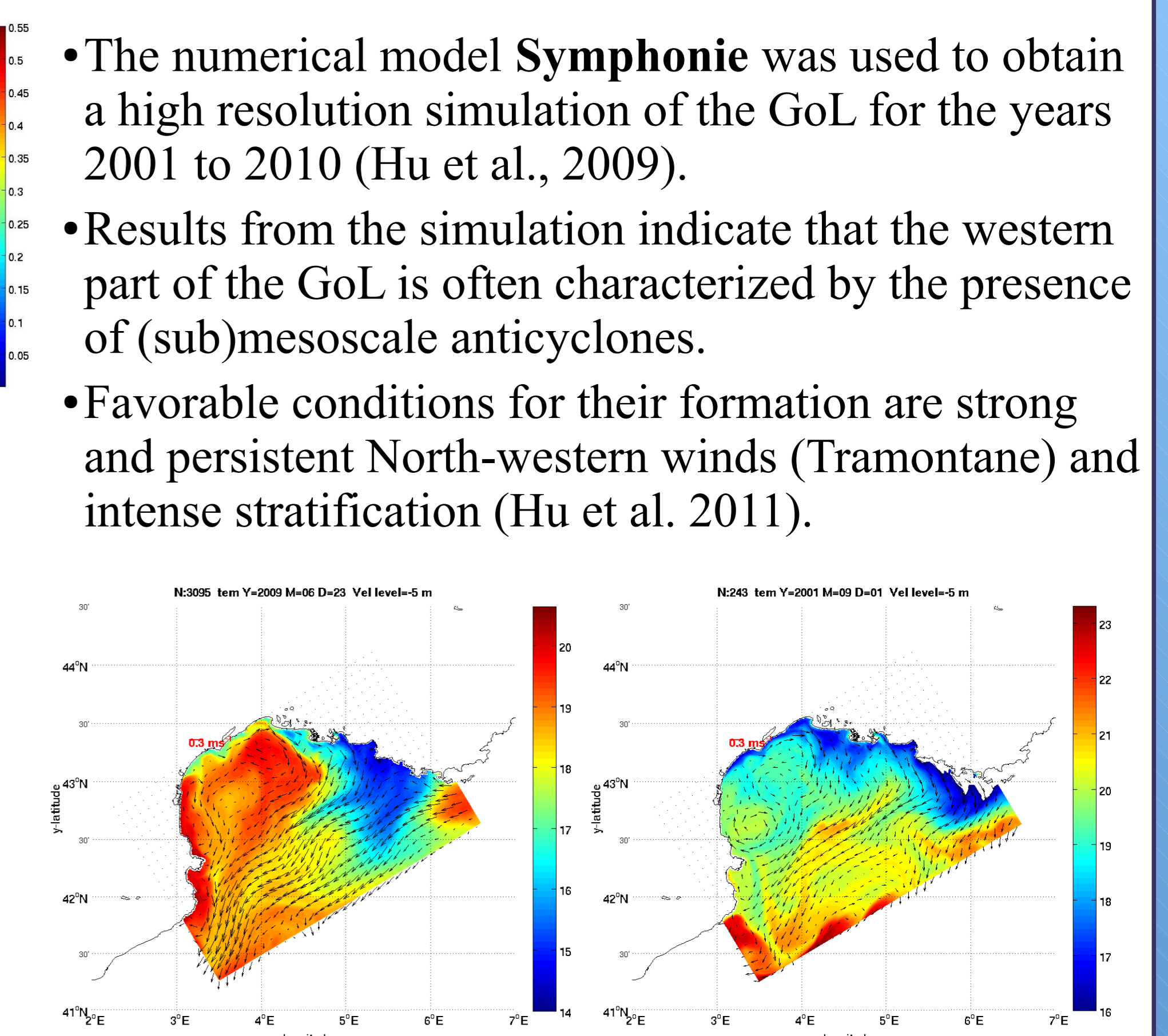
- The Latex10 experiment included a fleet of 3 gliders.
- Gliders are emerging as a suitable platform to investigate submesoscale structures and fronts.
- They can provide high resolution quasi-synoptic vertical sections (CTD and optical sensors), and their sampling strategy can be adjusted in near-real time.
- The temperature section from Sept. 10 to 14 evidences the vertical extent of the front and the depth of the tongue of colder water leaving the shelf.



Figures (and more info on gliders) from www.ego-network.org

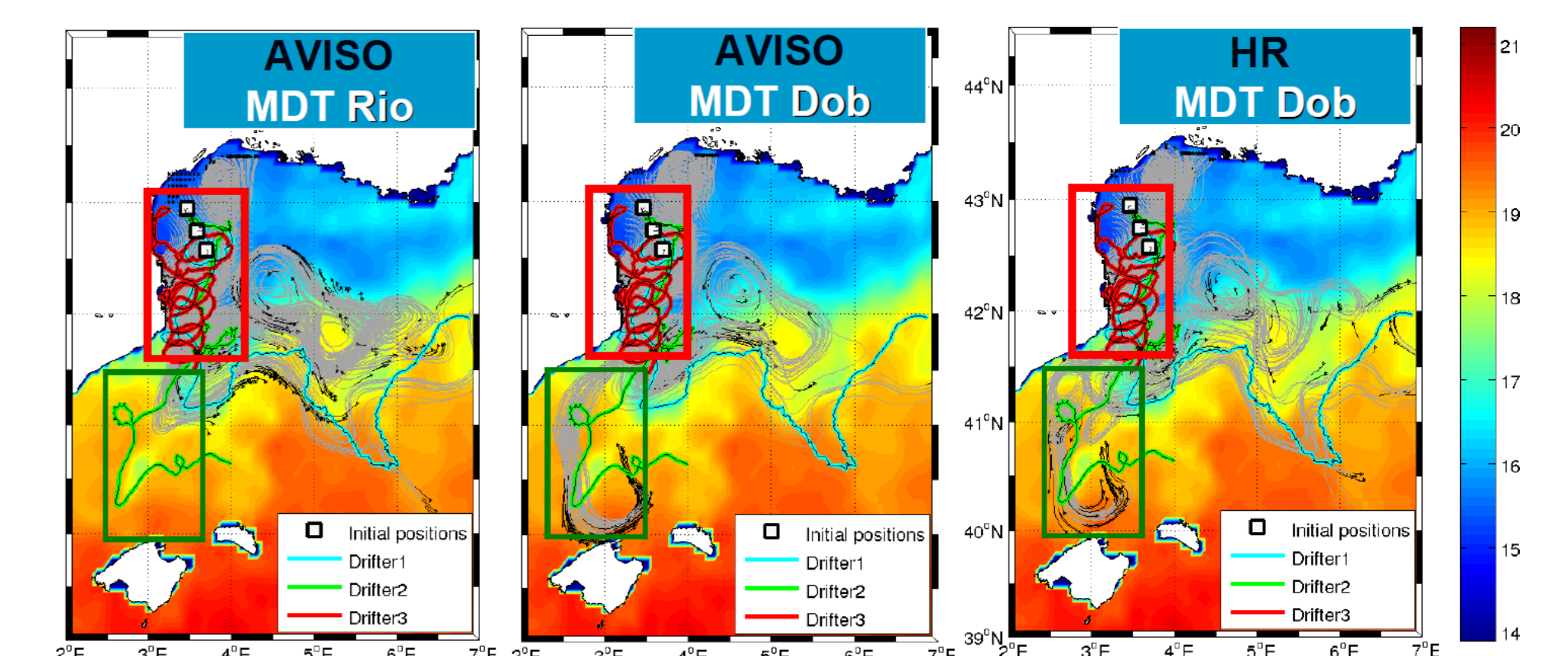
High-Resolution Numerical Simulations

- The numerical model **Symphonie** was used to obtain a high resolution simulation of the GoL for the years 2001 to 2010 (Hu et al., 2009).
- Results from the simulation indicate that the western part of the GoL is often characterized by the presence of (sub)mesoscale anticyclones.
- Favorable conditions for their formation are strong and persistent North-western winds (Tramontane) and intense stratification (Hu et al. 2011).
- These structures have a strong influence on transport patterns in the western part of the GoL.
- Results from the numerical simulation will allow to investigate how (sub)mesoscale structures modulate cross-shelf exchanges in the GoL.



Altimetry Derived Velocity Fields

- Due to limitations on their spatial and temporal resolution, current altimetry products can only provide limited information on submesoscale processes.
- Furthermore, satellite products have shown limited accuracy in coastal regions.
- Nonetheless, region-specific processing procedures for along track data can sensibly improve altimetry derived velocity fields.
- This can ultimately enhance the quality of the retrieved transport pattern information.



FUTURE PERSPECTIVES

- The Latex10 experiment confirmed the importance of LCSs for the analysis of horizontal transport in the coastal environment.
- Collected direct observations from multiple platforms allowed to accurately reconstruct the frontal structure and estimate its impact on cross-shelf exchanges during Sept. 2010.
- Integration of in-situ observation with numerical simulation and satellite data will allow a more complete characterization of (sub)mesoscale processes in the western part of the GoL and their impact in regulating coastal transport.

Acknowledgments

The authors warmly thank Ziyuan Hu for providing the figure of the numerical simulation domain. They thank the crew of the RV *Téthys II* for their help at sea during the Latex10 experiment. They acknowledge Météo-France for 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. More info on the LATEX project at: www.com.univ-mrs.fr/LOPB/LATEX

Bibliography

d'Ovidio, F., V. Fernández, E. Hernández-García, and C. López (2004), *Mixing structures in the Mediterranean Sea from finite-size Lyapunov exponents*, Geophys. Res. Lett., 31, L17,203.
 Hu, Z.H., Doglioli A.M., Petrenko A.A., Marsaleix P., Dekeyser I. (2009), *Numerical simulations of eddies in the Gulf of Lion*, Ocean Model., Vol. 28/4, pp. 203-208, doi:10.1016/j.ocemod.2009.02.004.
 Hu, Z.H., Petrenko, A.A., Doglioli, A.M., Dekeyser, I. (2011), *Numerical study of eddy generation in the western part of the Gulf of Lion*, J. Geophys. Res., Res., 116, C12030, doi:10.1029/2011JC007074.
 Nencioli F., F. d'Ovidio, A. Doglioli and A. Petrenko, (2011), *Surface coastal circulation patterns by in-situ detection of Lagrangian Coherent Structures*, Geophys. Res. Lett., Vol 38, L17604, doi:10.1029/2011GL048815.