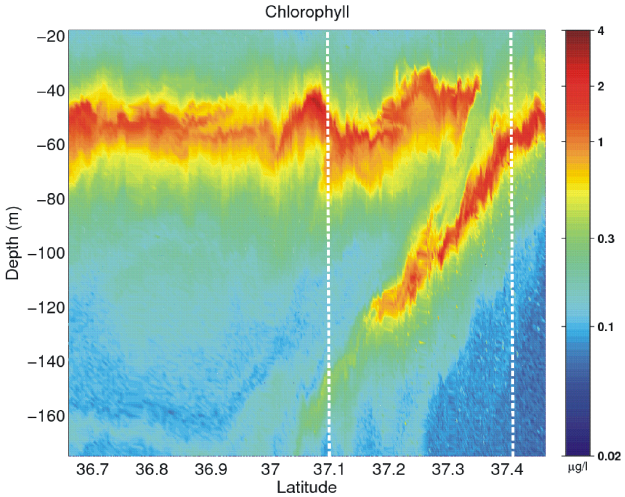
Coherent Lagrangian Pathways from the Surface Ocean to Interior

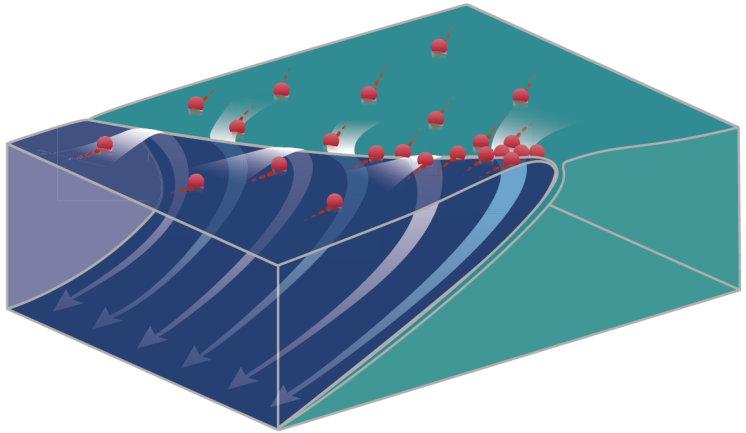
Ananda Pascual (IMEDEA, Spain) on behalf of the CALYPSO team

CALYPSO objectives

Unravel the three-dimensional coherent pathways by which water carrying tracers and drifting objects is transported from the surface ocean to depths below the mixed layer.



Ruiz et al. 2009

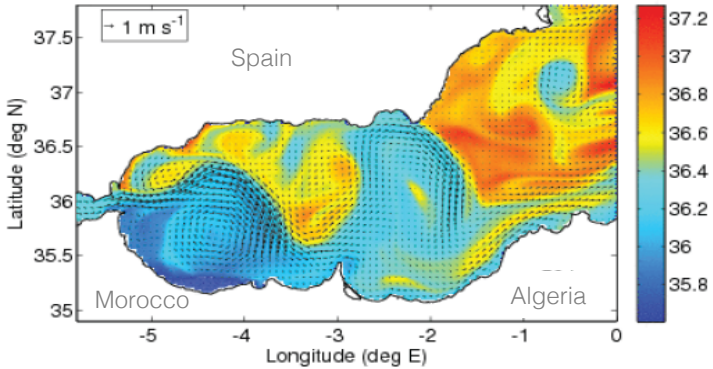


D'Asaro et al. 2018

Technical approach

- Focus on South Western Mediterranean
  - Strong meandering current and front
  - Deep subduction previously determined
- Experiments in July 2017, May/June 2018, March 2019
- Experiment planned for 2020/2021
- Modeling - multi-scale approach
- Lagrangian perspective /coherent structure detection

WMOP - ROMS



CALYPSO meeting – Pollensa (Mallorca), 6-7 June 2019

CALYPSO meeting – Pollensa (Mallorca), 6-7 June 2019

Goals of the meeting:

1. Present preliminary results
2. Make plans for publication
3. Plan for 2020/2021 field work

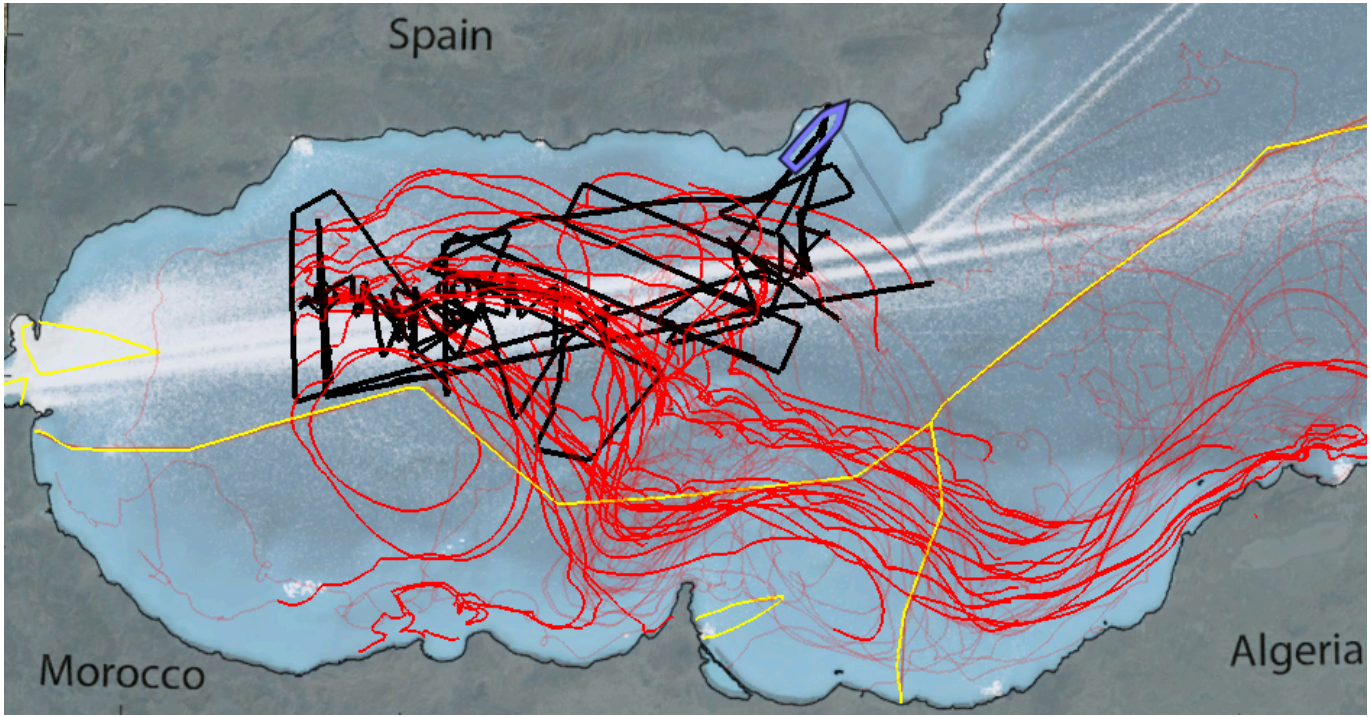
- Presentations + working groups discussions and reports
- Synergies with other programs (SWOT Adopt a Cross-Over) and groups (MIO, SHOM)

CALYPSO 2019

E. D'Asaro (UW), A. Mahadevan (WHOI)

Chief Scientists

RV Pourquoi Pas ? March 28 – April 11, 2019

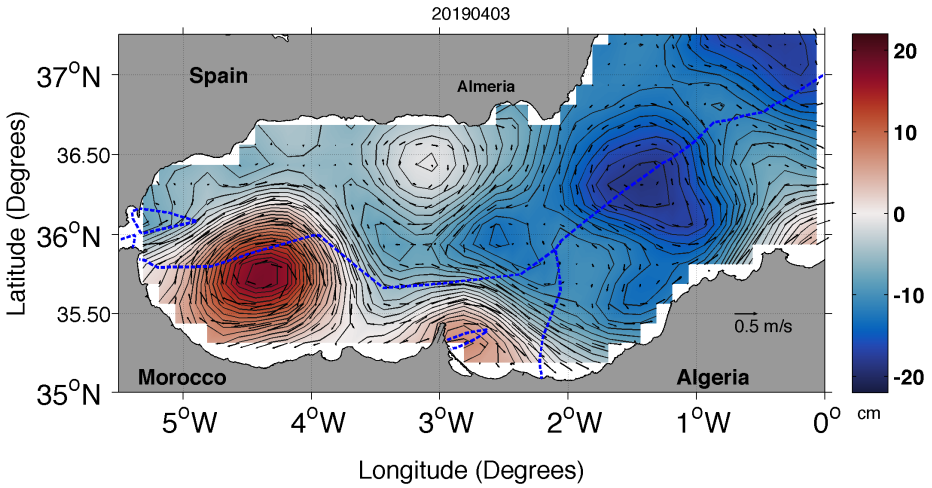


CALYPSO 2019

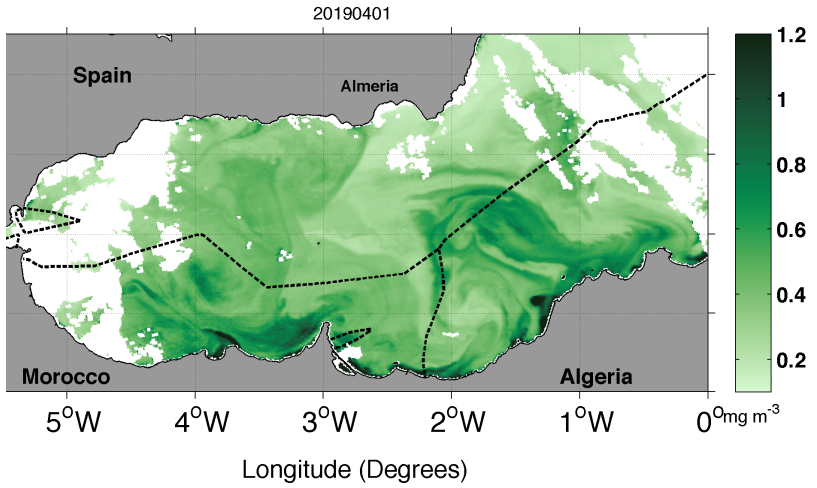
S. Ruiz (IMEDEA)

Satellite context

Altimetry



Ocean Color

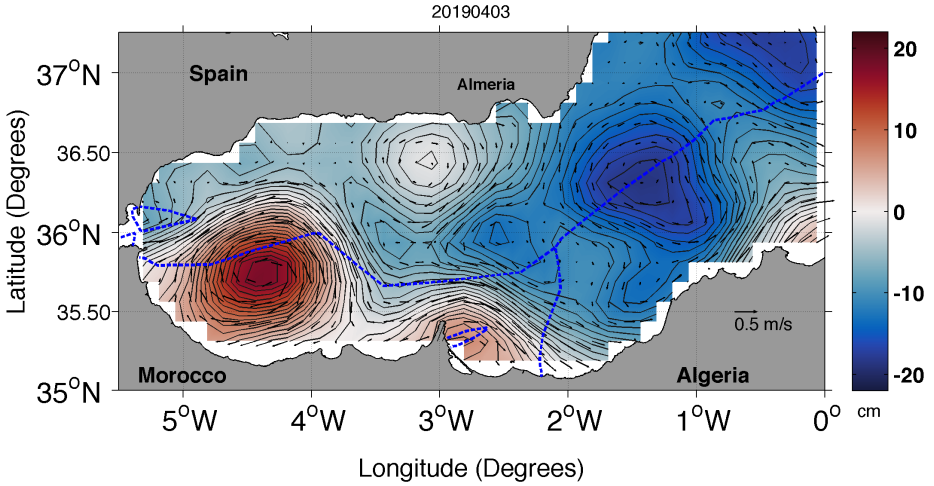


CALYPSO 2019

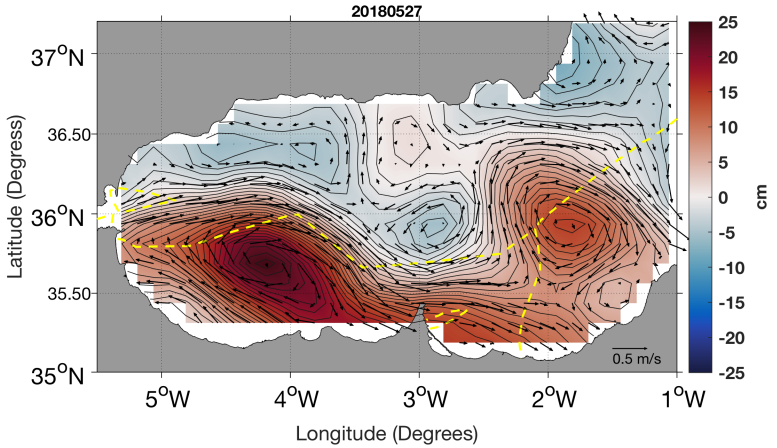
S. Ruiz (IMEDEA)

Satellite context (altimetry)

2019



2018

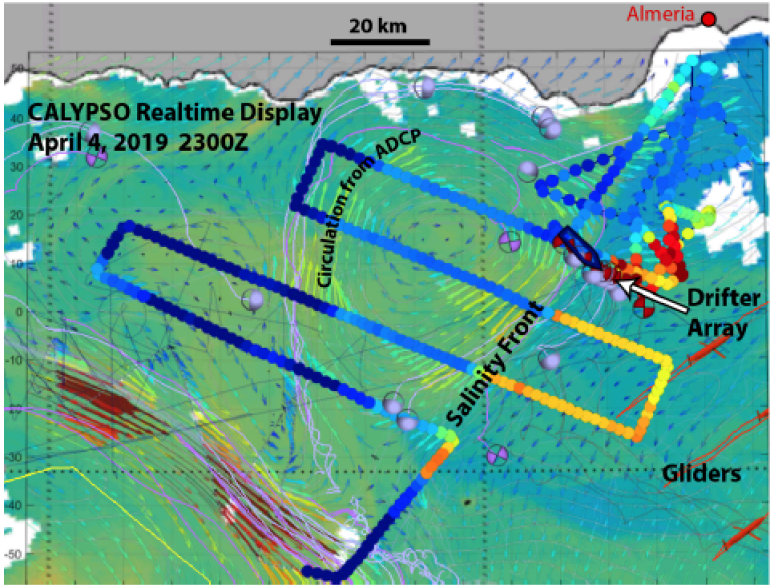


CALYPSO 2019

E. D'Asaro (UW), A. Mahadevan (WHOI)

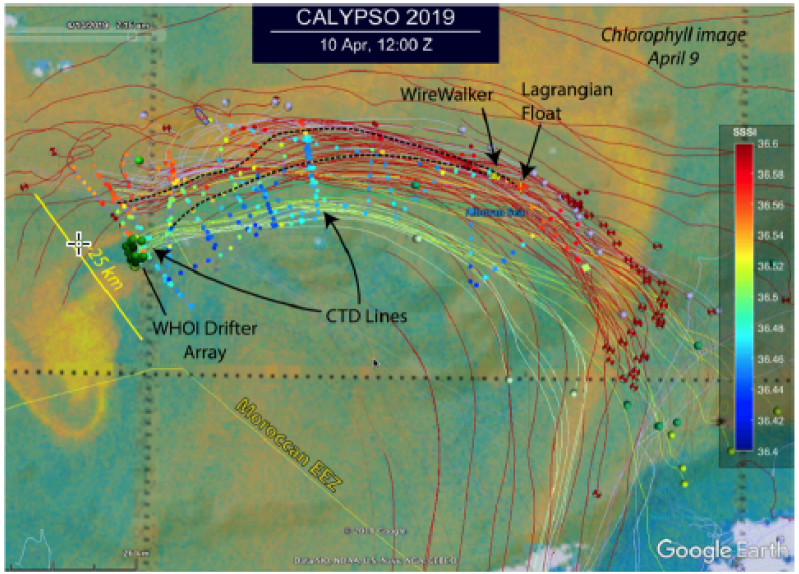
RV Pourquoi Pas ?

March 28 – April 4, 2019



LEG 1 : uCTD, ADCP, Microstructure, SVP & CODE Drifters, ARGO, CTD: flow cytometry, DNA

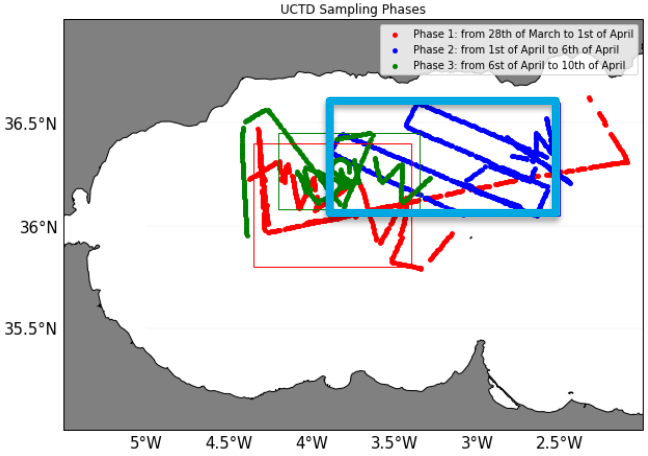
April 4 – April 11 2019

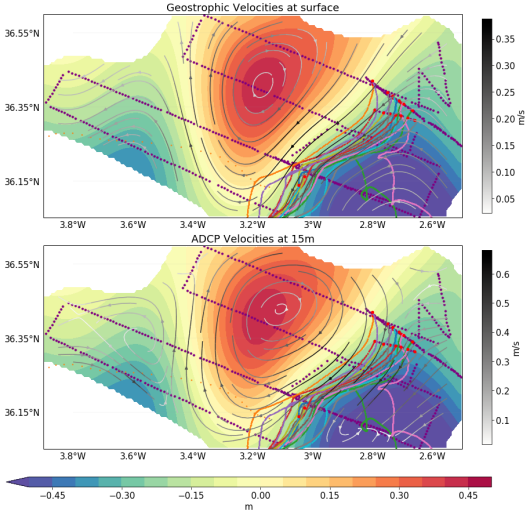


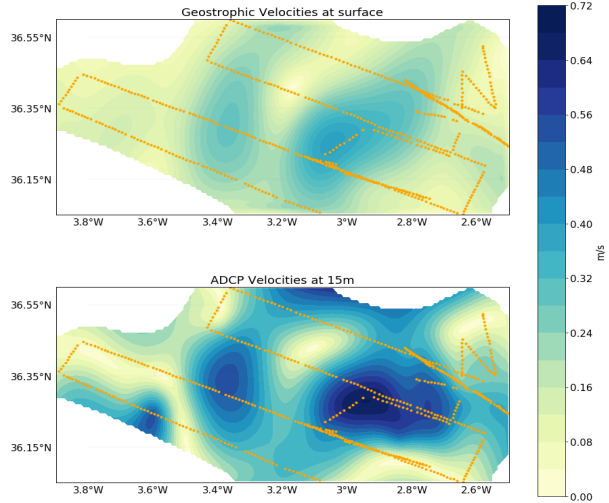
LEG 2 : u/ecoCTD, ADCP, profling floats, CTD: cytometry, DNA, Lagrangian floats, V-Wing, WireWalker, Drifters: SVP,CODE, CARTHE, WHOI

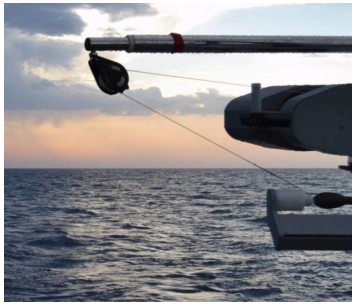
uCTD

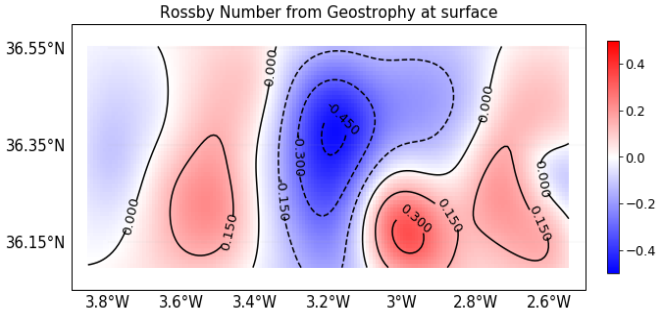
E. Cutolo (IMEDEA)

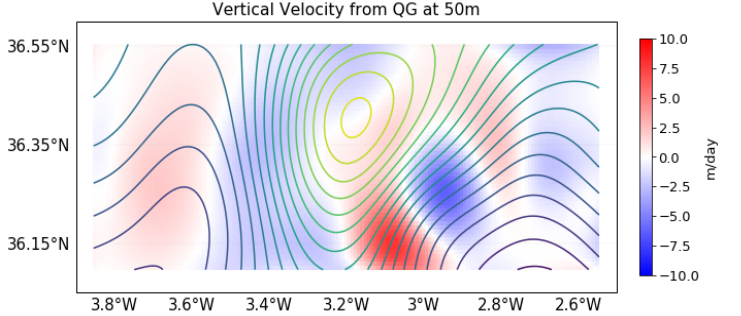






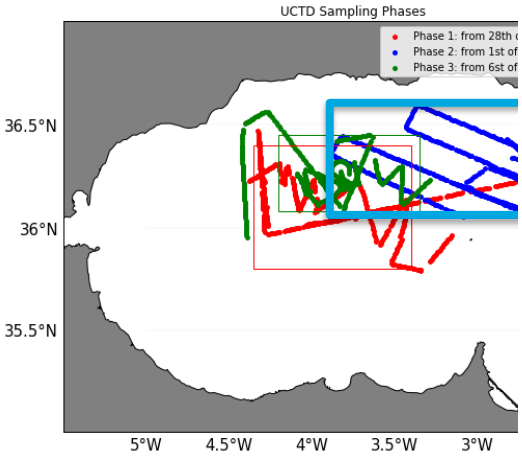


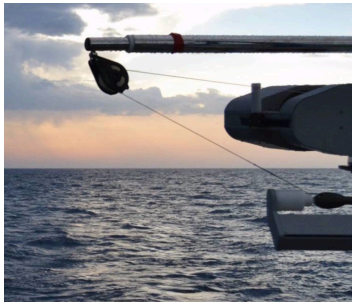


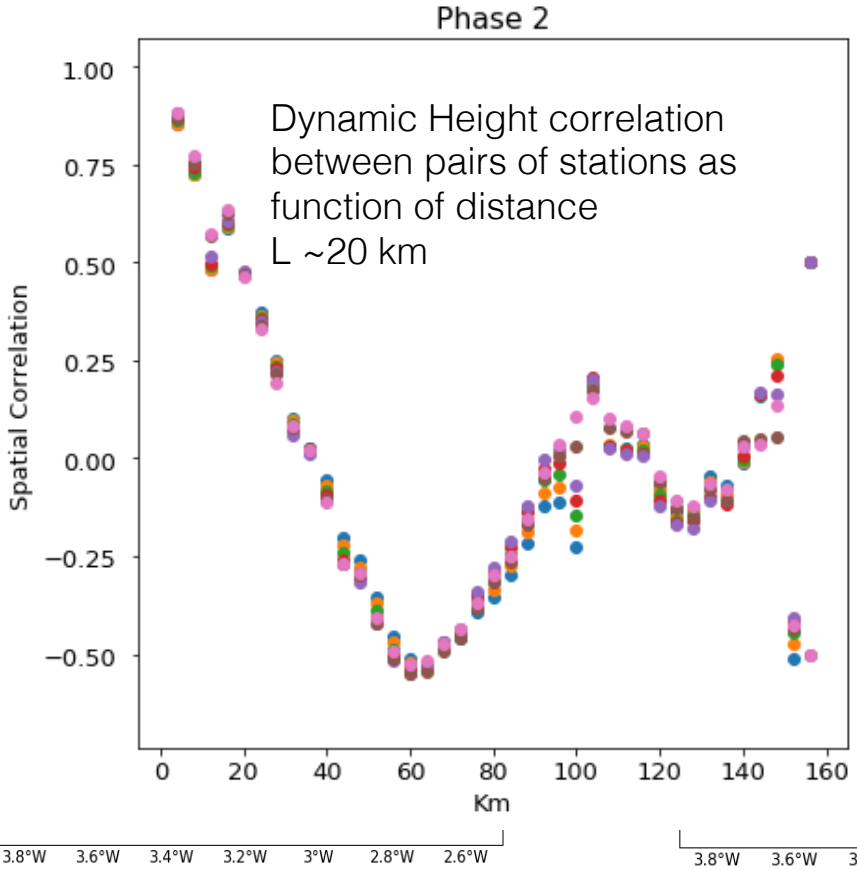


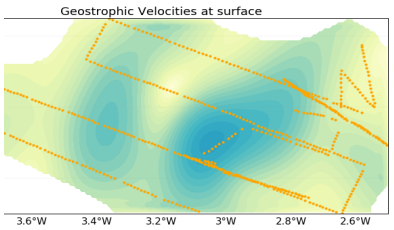
uCTD

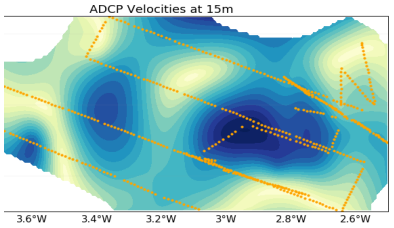
E. Cutolo (IMEDEA)

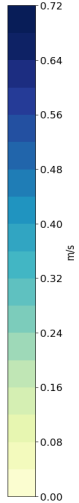


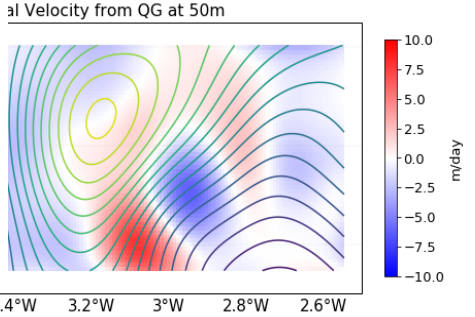








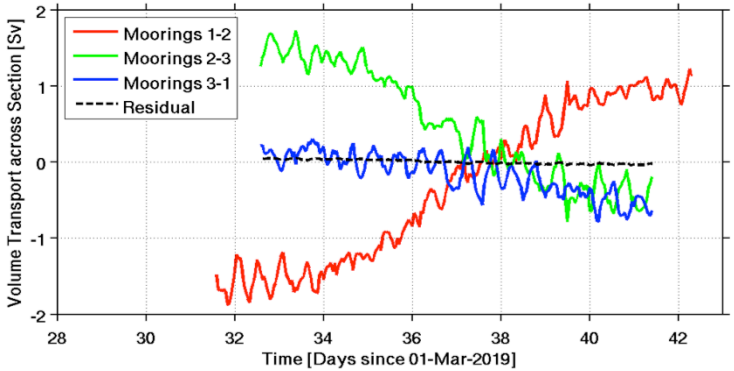


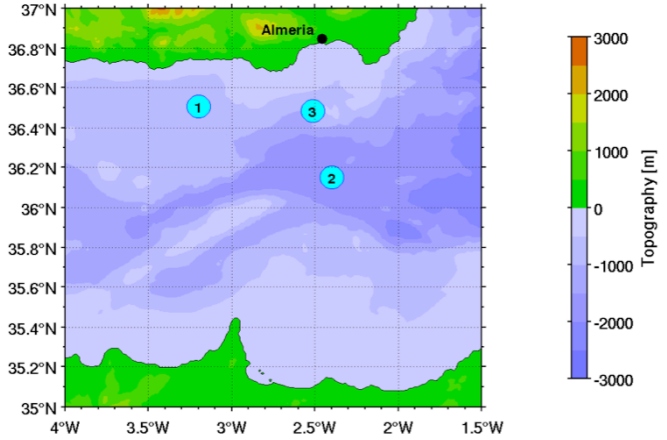


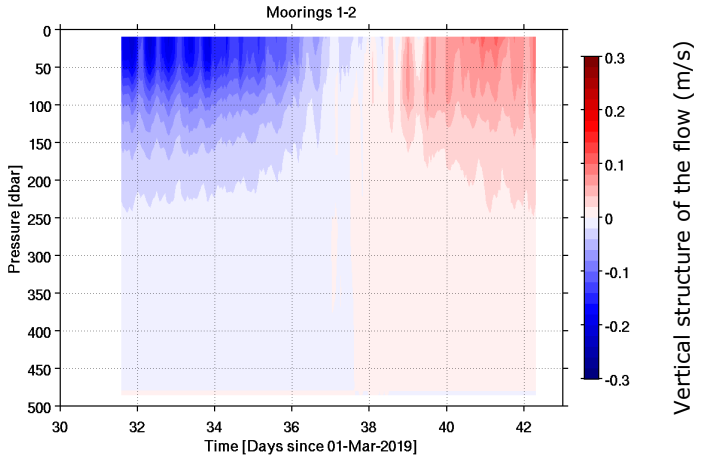
Moorings 2019

U. Send (SIO)

- Each measures temperature and salinity with 7 instruments in approximately upper 500 m.
- Real-time data delivery
- Geostrophic currents and transport. Upper 500 m, relative to 500 m.
- Transport is ± 1.5 Sv between pairs of moorings
- Signal reverses over duration of 6 days

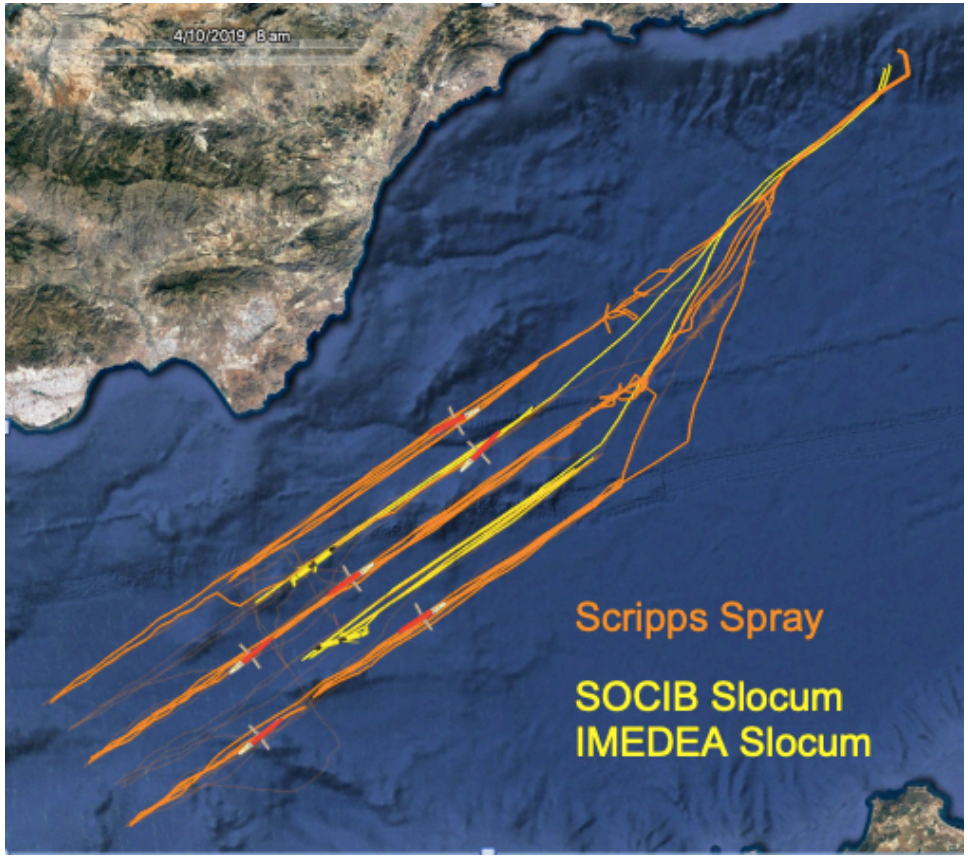






Underwater glider surveys 2019

D. Rudnick (SIO)



20 March - 20 May 2019

400 glider-days

9300 km

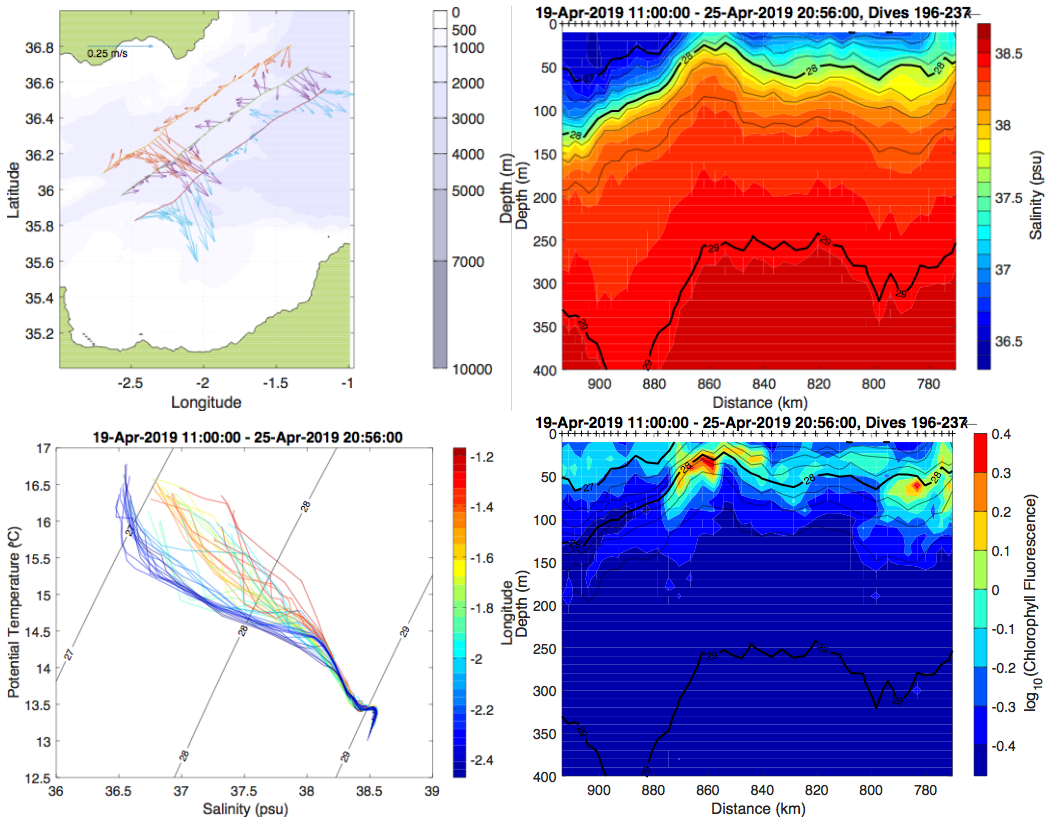
2400 dives

Surface to 700 m

> 60 sections

Glider sections 2019

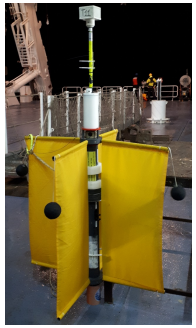
D. Rudnick (SIO)



- Southern section
- Strong confluent front
- Surface layer deepens to south
- Suggestion of across-front convergence

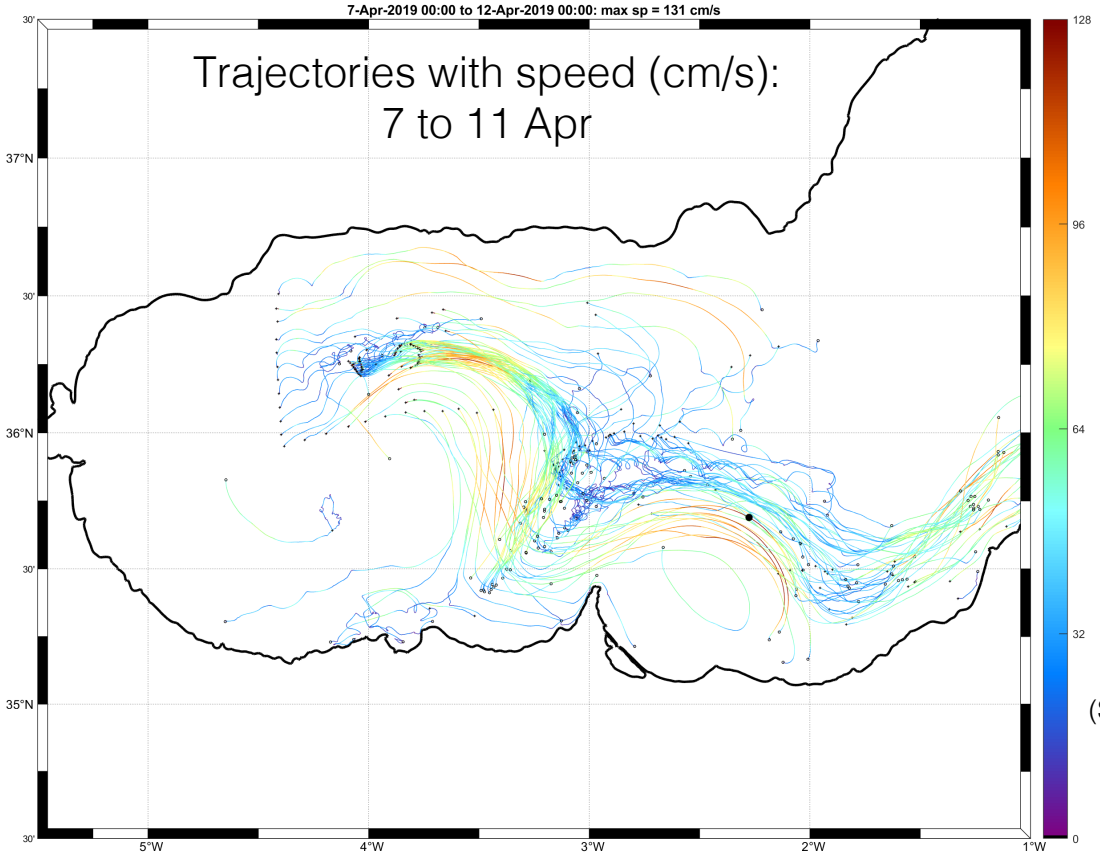
Drifter trajectories 2019

P.-M.Poulain (CMRE), T. Ozgokmen (RSMAS), L. Centurioni (SIO)



1 CODE-ADCP
(OGS)

100 CARTHE
(RSMAS)



25 CODE
(CMRE)

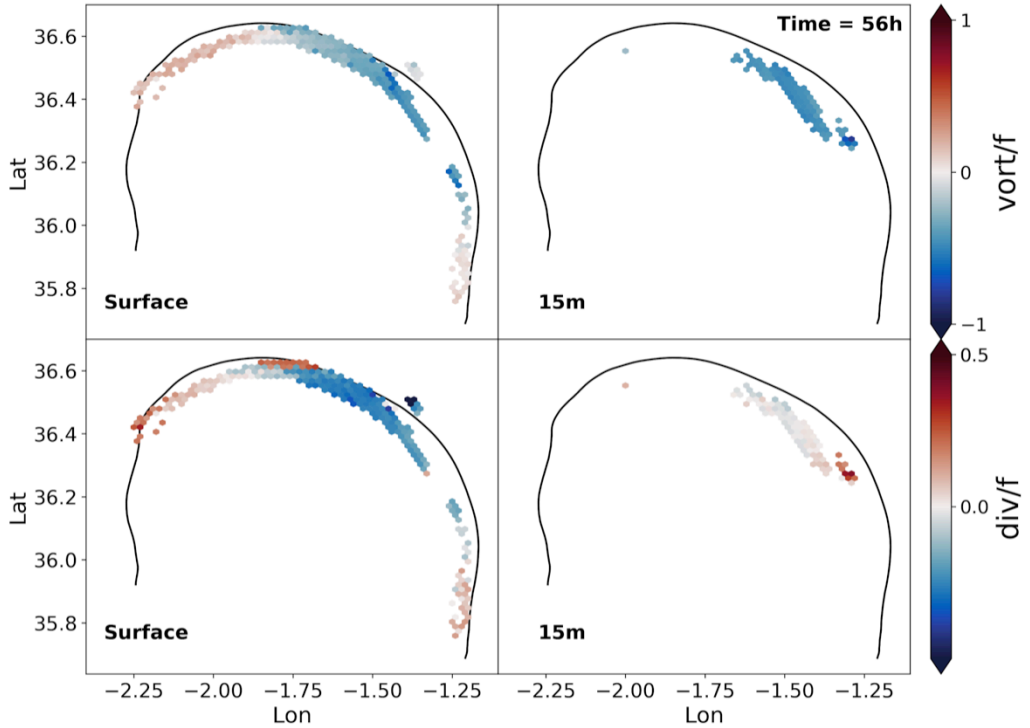
6 DWS
(SIO)

53 SVP
(SIO, OGS)

Kinematic properties from drifters

D. Rodríguez-Tarry (IMEDEA)

Dataset from CALYPSO 2018 cruise – Least Square Method (Molinari et al. 1975; Essink et al. 2019)



Bin plots (scales 10-40 km, hourly estimations):

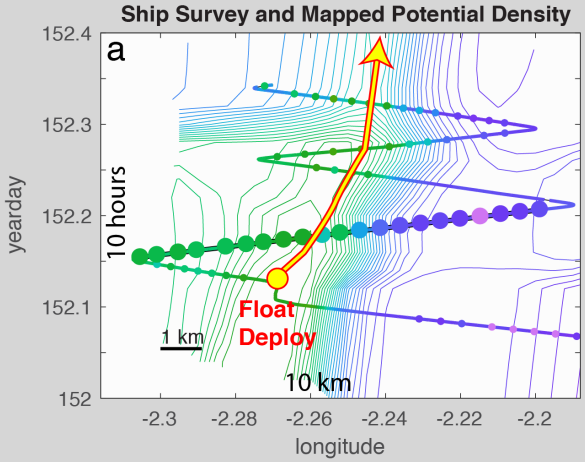
Drifters show coherent signals of convergence (order 0.5 f)

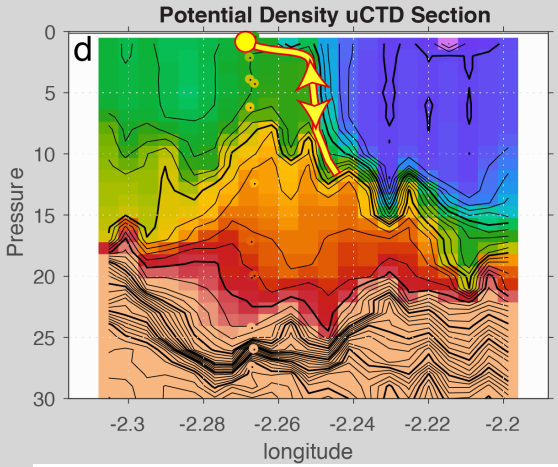
Vorticity values around 0.5 f.

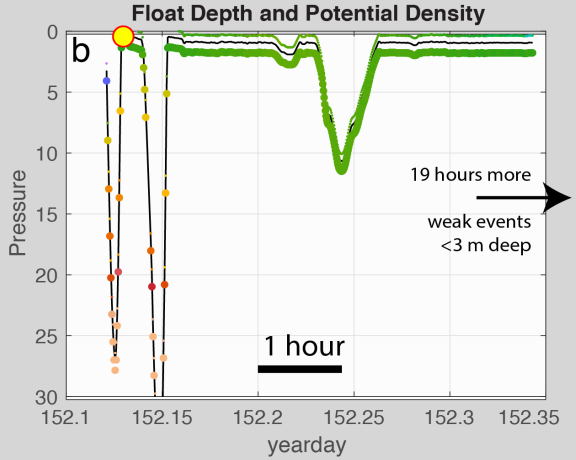
CALYPSO 2018

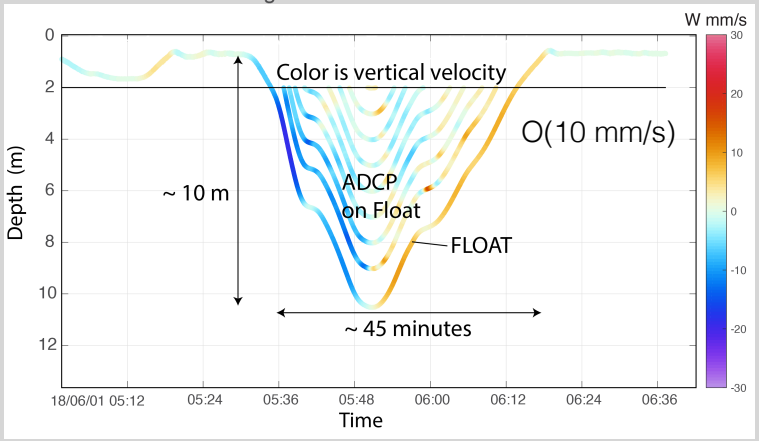
Submesoscale front with shallow subduction

E. D'Asaro (UW)

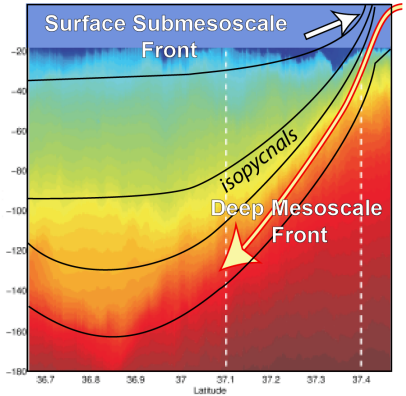




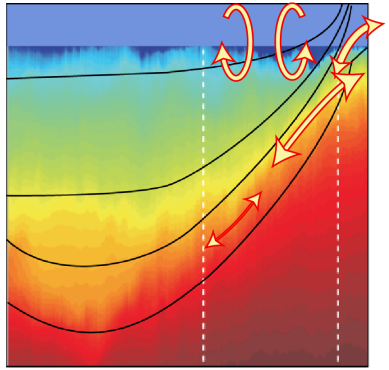




Simple Cartoon



Wiser Cartoon

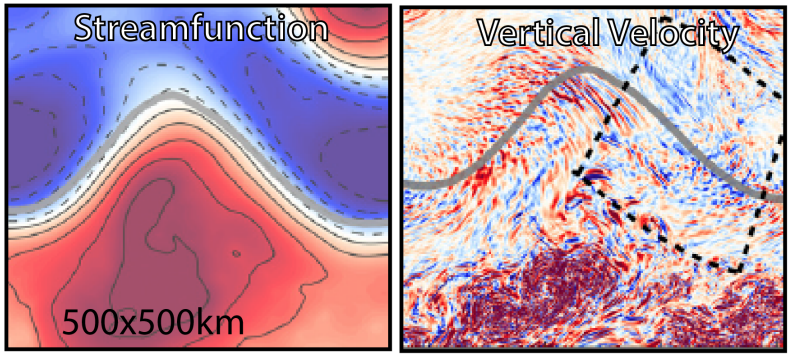


We measure energetic upward and downward vertical motions near the surface with superinertial frequencies and submesoscale spatial scales.

Coherent structures?

Ruiz et al. 2009

This is consistent with models



McWilliams, Gula, Molemaker 2019

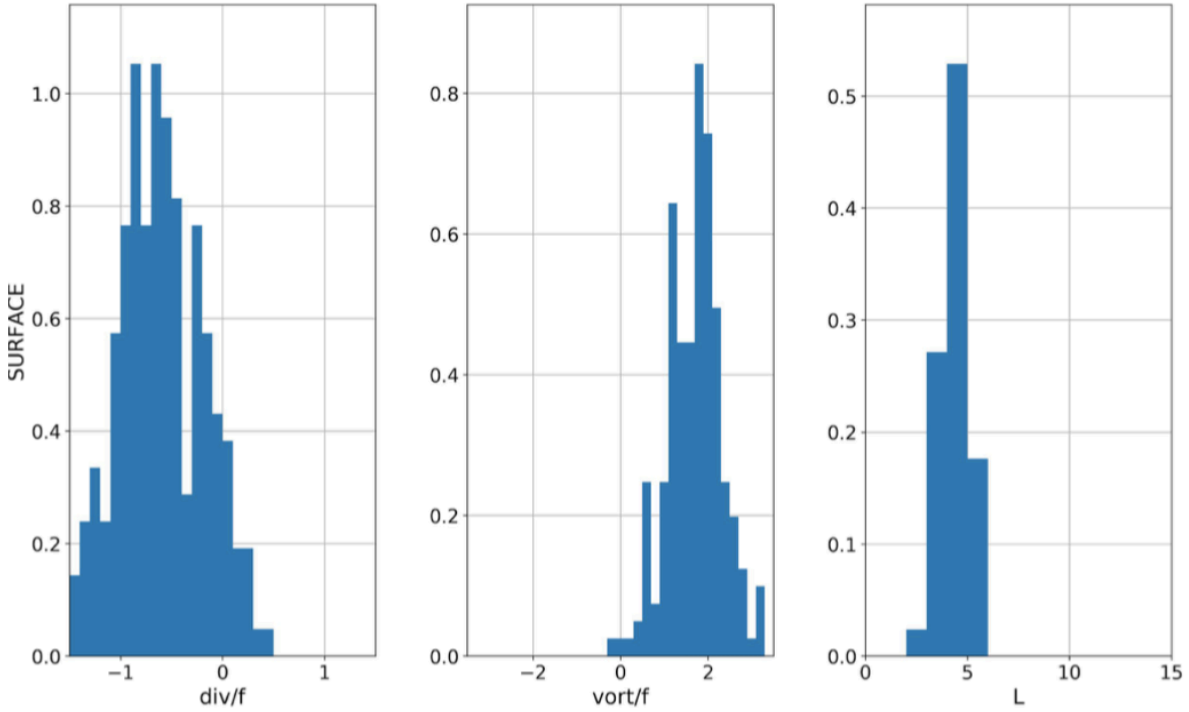
Spectrum is roughly white
Small scales dominate energy

These are "invisible" in SSH

Kinematic properties from drifters

D. Rodríguez-Tarry (IMEDEA)

In the area of the float subduction – encouraging preliminary results



PDF (scales <10km, 20 min estimations)

- Surface drifters show signals of convergence O(f)
- Vorticity values around 2 f.

Summary and future plans

- Vertical velocity is complicated !
- Need of multiple ‘toys’
- Further analysis (observations and modeling). Tighter coupling with forecasting models, data assimilation
- Potential synergies with SWOT
- Experimental plan 2020-2021 (drift-air, more floats, AUVs,…)
- Working groups (modeling, lagrangian, sampling strategy, location, biogeochemistry,..)
- Next meeting in 6 months

CARTHE Drift-AIR

T. Ozgokmen

Test in Gulf of Mexico two weeks ago

A. Scherbina