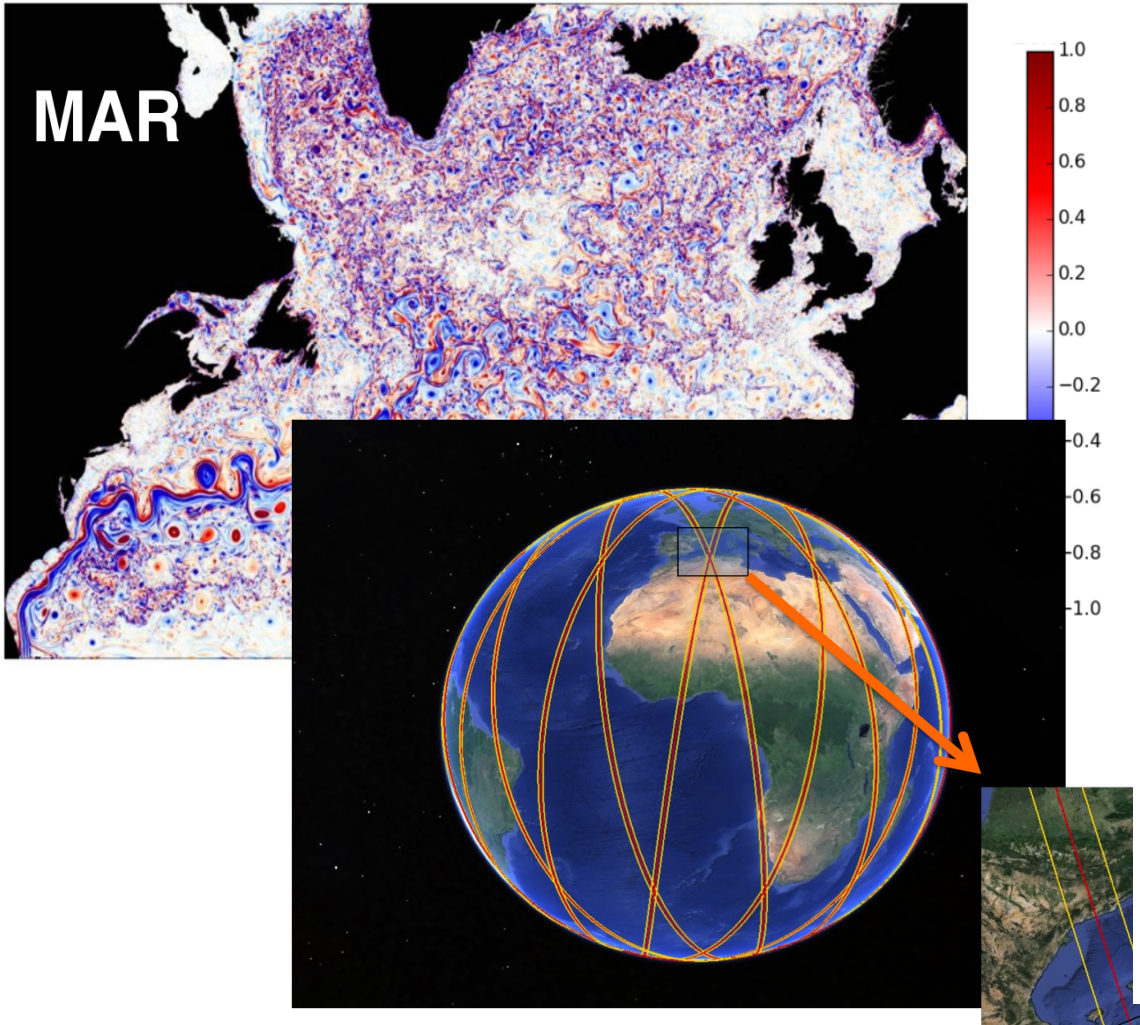
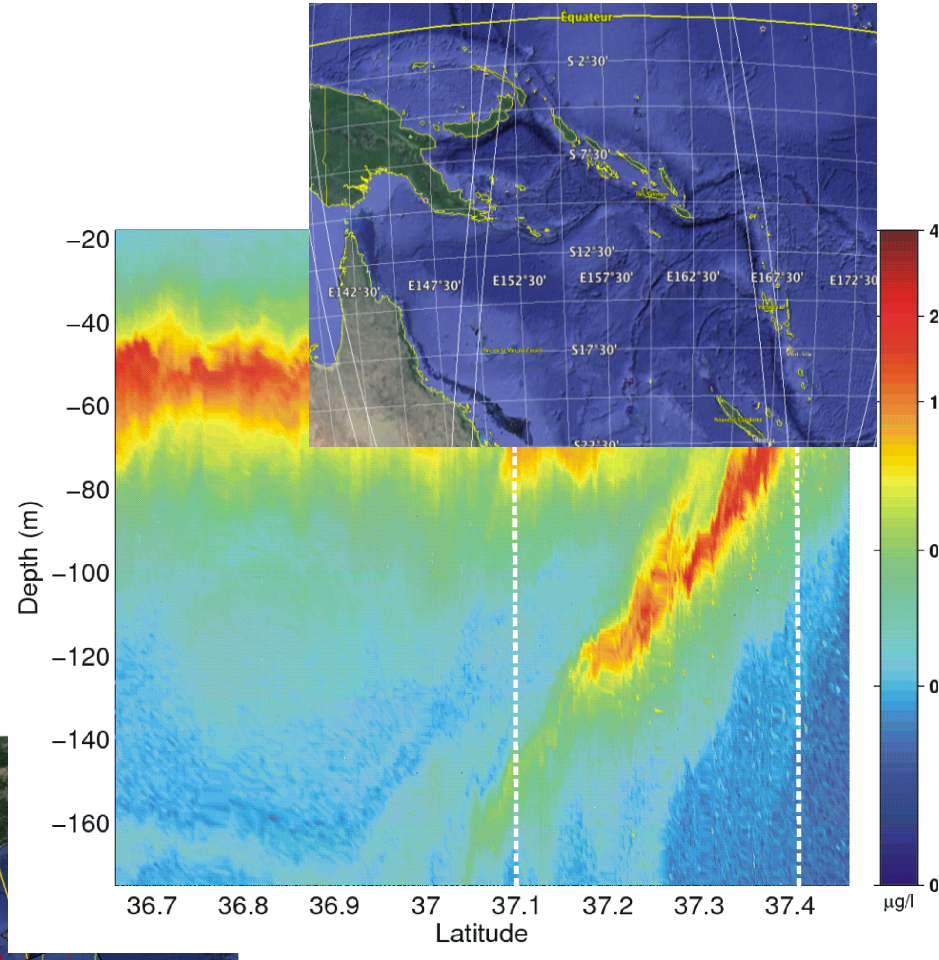
Meso- and submesoscale observations and OSSE





Physics

Which processes will be accessible with SWOT?
Where?

CalVal & process
In situ campaigns

- New experimental competences
- Regional partnerships
- 2021 submesoscale campaign

Physics

Which processes will be accessible with SWOT?
Where?

Biogeochemistry

Which biogeochemical uncertainties can be reduced by SWOT?

CalVal & process In situ campaigns

- New experimental competences
- Regional partnerships
- 2021 submesoscale campaign

Physics

Which processes will be accessible with SWOT?
Where?

Biogeochemistry

Which biogeochemical uncertainties can be reduced by SWOT?

Ecology

How do the physical fine scales impact:

- Marine biodiversity?
- Fish distribution?

CalVal & process In situ campaigns

- New experimental competences
- Regional partnerships
- 2021 submesoscale campaign

Mesoscale and submesoscale variability

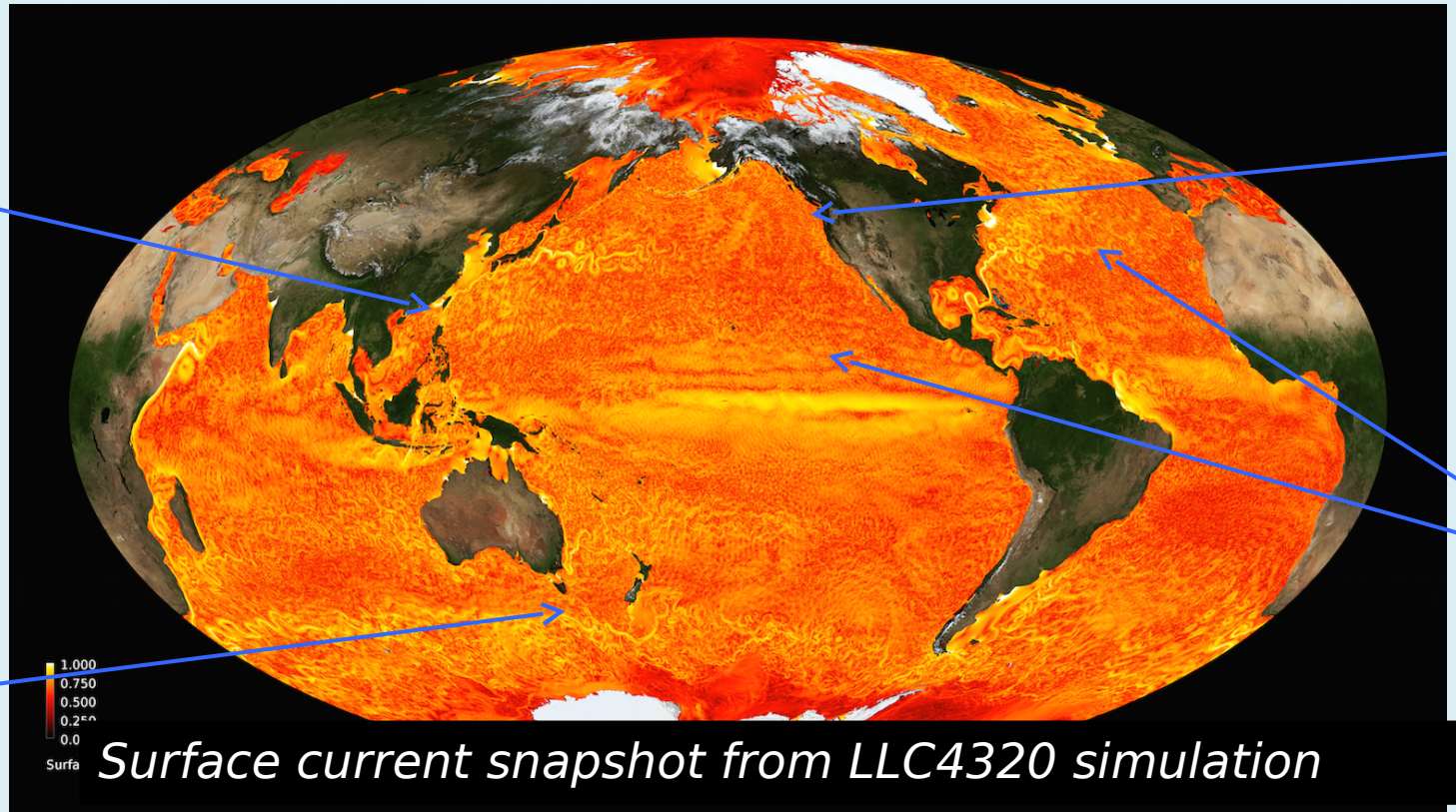
Kyla Drushka[1], Luc Rainville[1], Dimitris Menemenlis[2]
1. Applied Physics Lab, 2. JPL

Objective: Develop tools to separate the mesoscale and submesoscale SSH signals from SWOT observations.

Approach: Exploit historical Seaglider data and a high-resolution model simulation to characterize (sub)mesoscale ocean variability in different regimes.

Kuroshio Current origin region

Washington coast



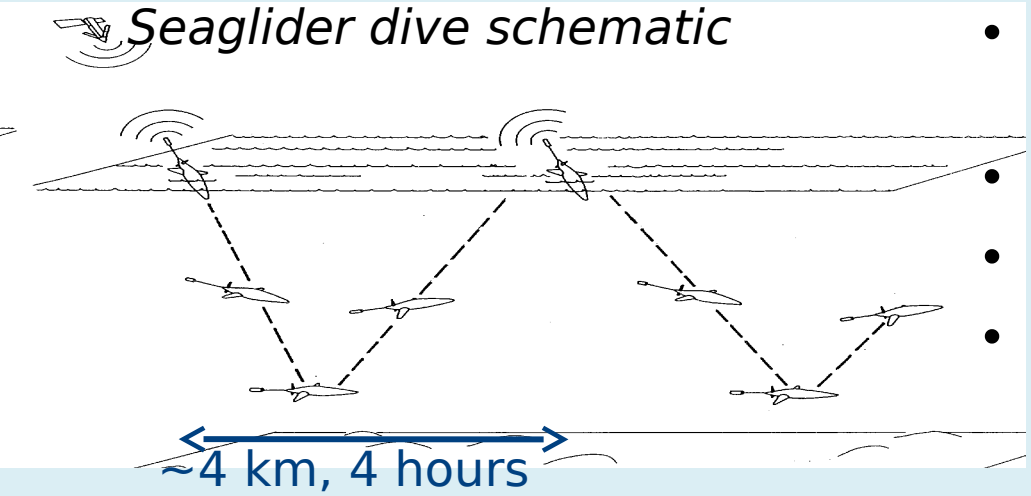
Surface current snapshot from LLC4320 simulation

Tasmania

SPURS-1 and -2 field experiments

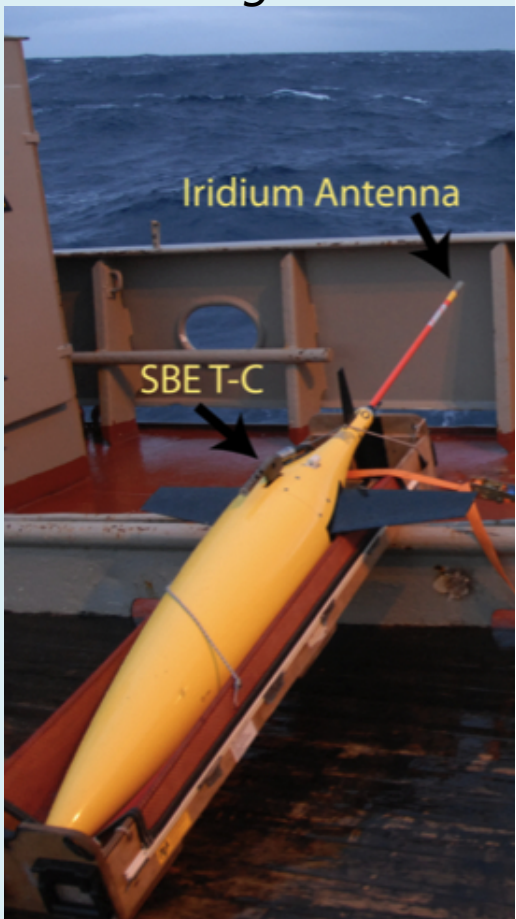
Mesoscale and submesoscale variability

Seaglider dive schematic

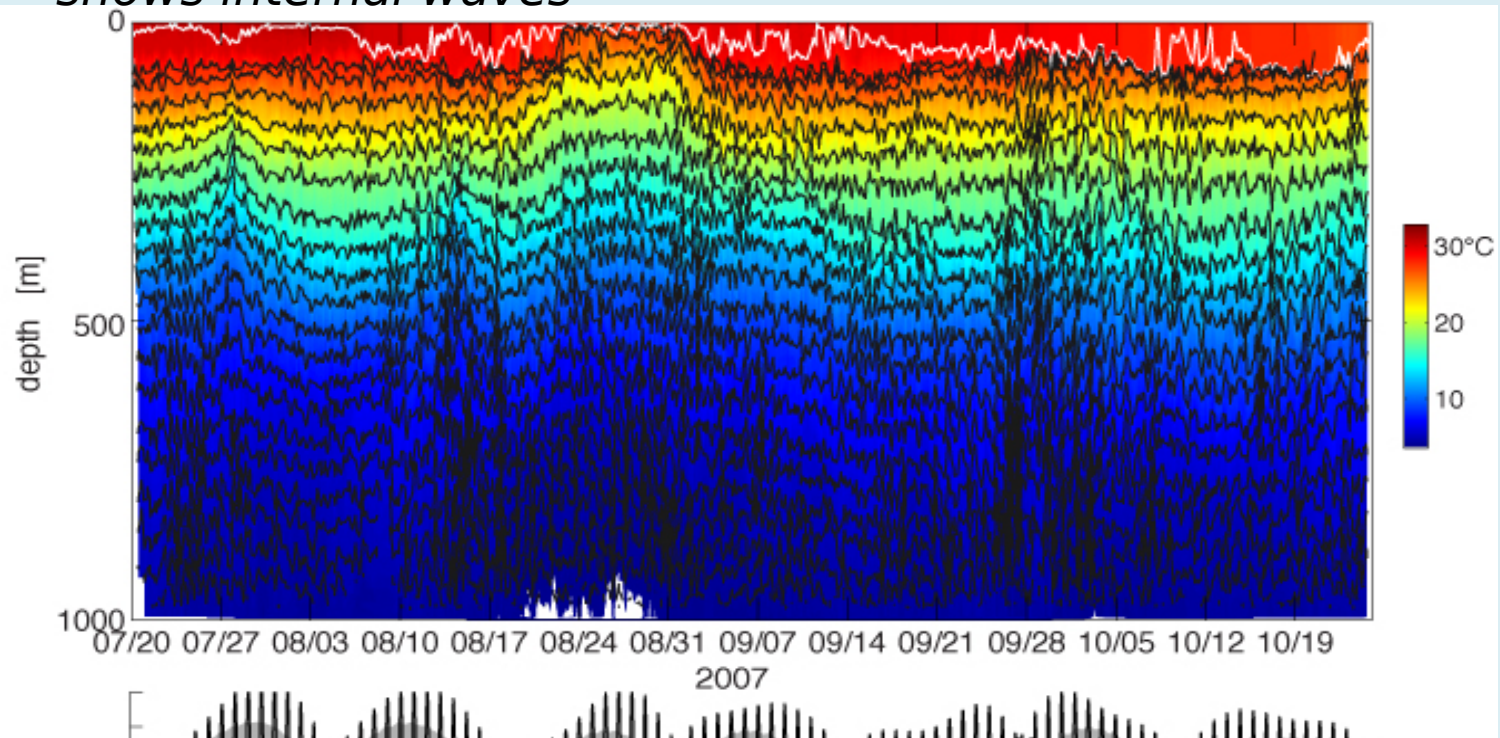


- Profiles down to 1000 m, 3-4 times / day
- Travels 20 km / day
- 6-9 month deployments
- **T&S profiles → dynamic height: internal tides, mesoscale eddies**

Seaglider



Example: Depth-time map of ocean temperature shows internal waves



Mesoscale and submesoscale variability

Specific Objectives

Use data from 6 distinct regions with long Seaglider time series (plus others?), LLC4320 1/48° model simulation, and SWOT simulator to:

1. **Characterize 15-100 km SSH variability**

   Wavenumber spectra, internal tides, mesoscale eddies from Seaglider and SWOT

2. **Determine what SWOT will see**

   Model output + SWOT simulator + statistics from (1)

3. **Develop strategies for cal/val efforts & future observation systems**

SWOT in the tropics :

A case study in the South West Pacific

L. Gourdeau, F. Marin, A. Ganachaud

SCIENTIFIC OBJECTIVES

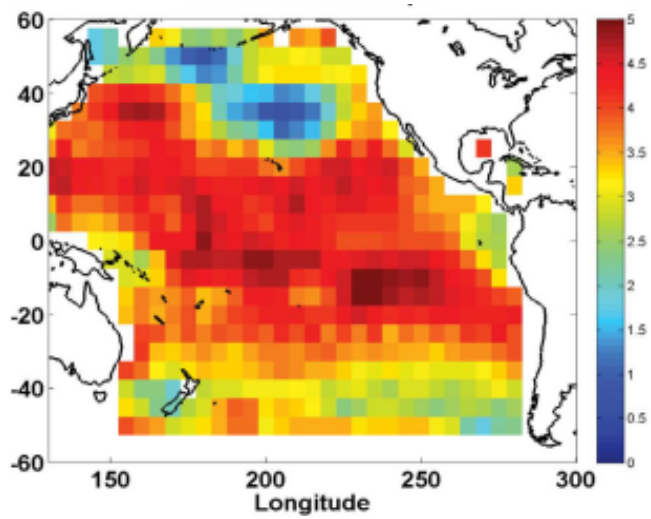
- SWOT observability in the tropics
- Interaction of meso/submesoscales with ocean circulation
- Cal/val & process study experiment

Objective 1: Spectral slopes

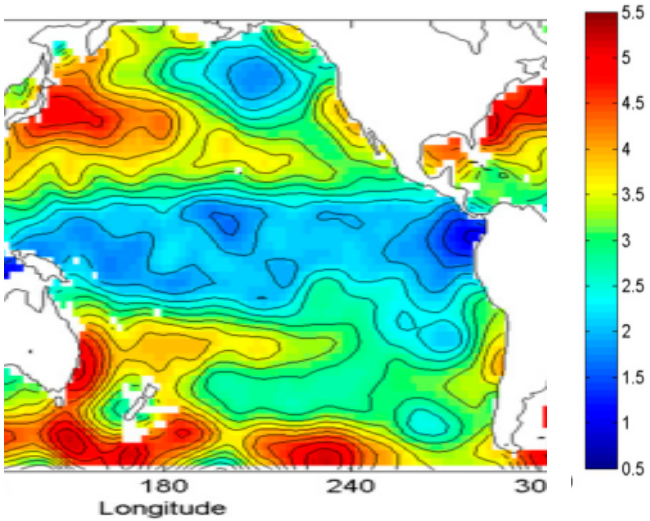
Discrepancy in the 70-250 km wavelength range:

Mesoscale SSH slope

from model (Richman et al., 2012)



from altimetry (Zhou et al., 2015)



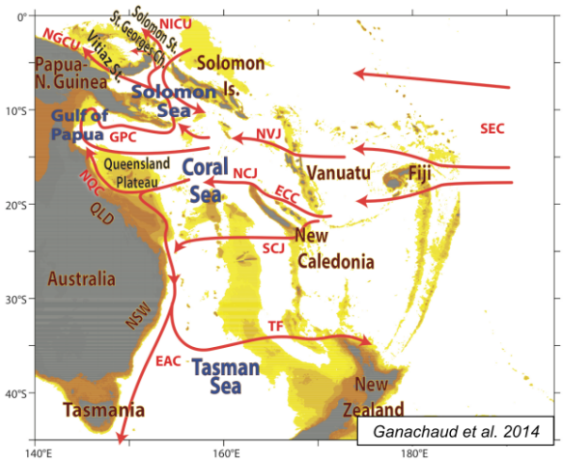
Objective 2: Geostrophy vs. ageostrophy

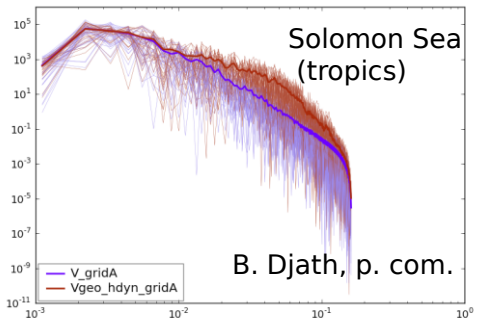
Effect of **Mixed Layer Instability** on velocity spectrum

Effect **of internal tides** on SSH spectrum

Zoom on the South West Tropical Pacific

Circulation is highly constrained by bathymetry and islands, and strong Western Boundary currents flow along the coast.

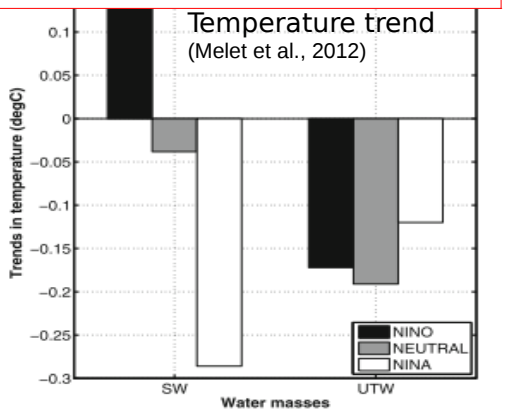


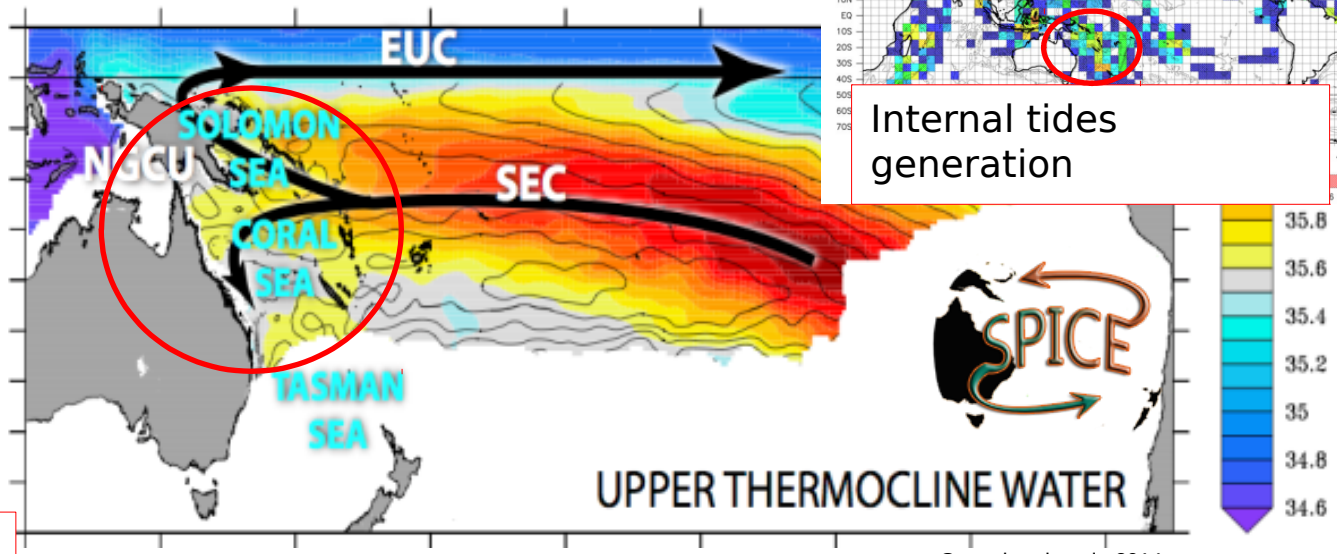


 use of a 1/36° regional simulation with explicit tides

Objective 3:
Feedback of mesoscale/submesoscales to the large scale circulation

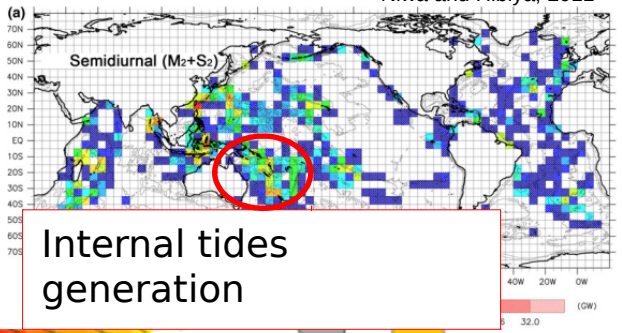
Water mass transformation





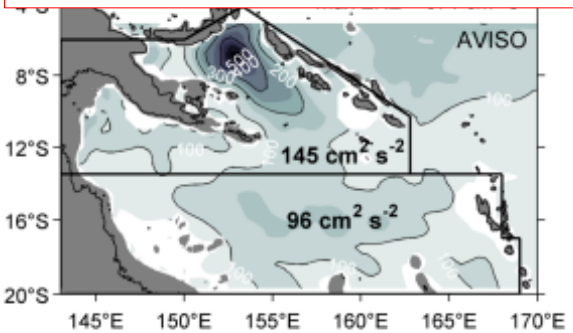
Ganachaud et al., 2014

Niwa and Hibiya, 2011



Internal tides generation

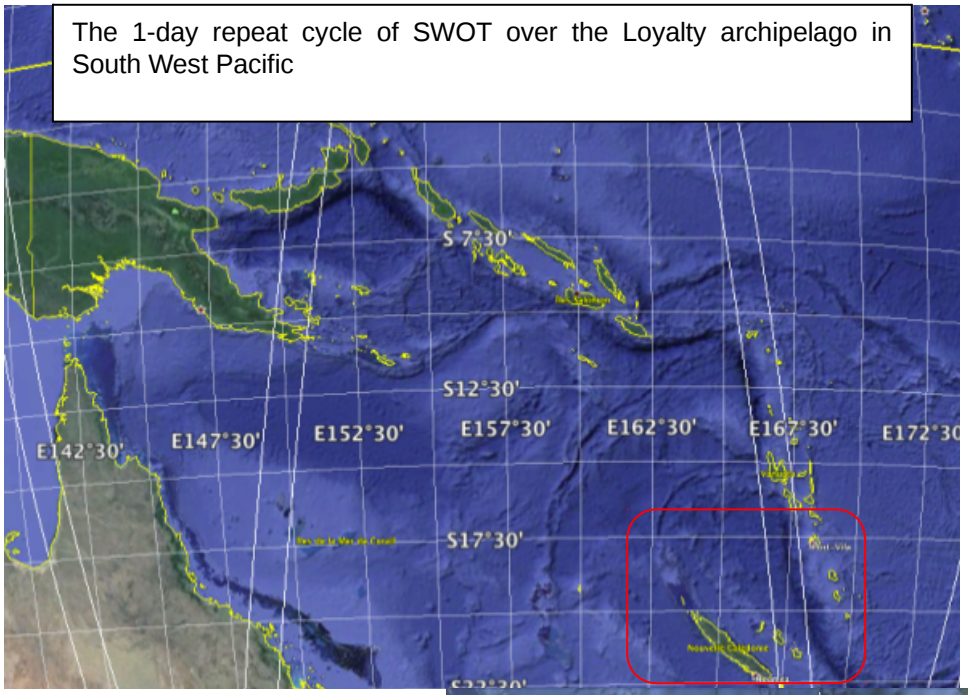
High level of mesoscale activity



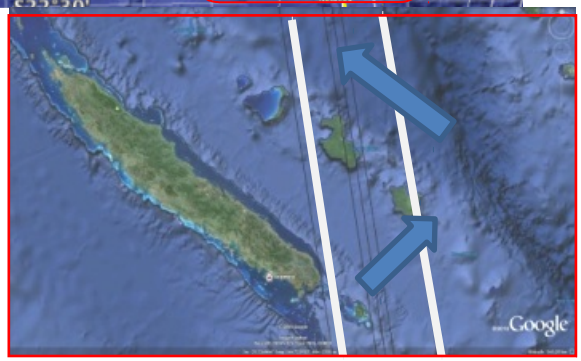
The south-west tropical Pacific is clearly a challenging area for SWOT observations

Objective 4: Cal/Val & process experiment

- Off the coast of New Caledonia
- during the 1-day repeat cycle period of the SWOT mission.



The 1-day repeat cycle of SWOT over the Loyalty archipelago in South West Pacific



- The swaths will cross the Vauban Current and the East Caledonian Current
- The IRD center at Noumea is an appropriate basis for *in situ* experiments.
- This area has been actively studied for the validation of Saral/AltiKa (AltiGlidex/TOSCA project, P.I.s F. Marin, F. Durand)

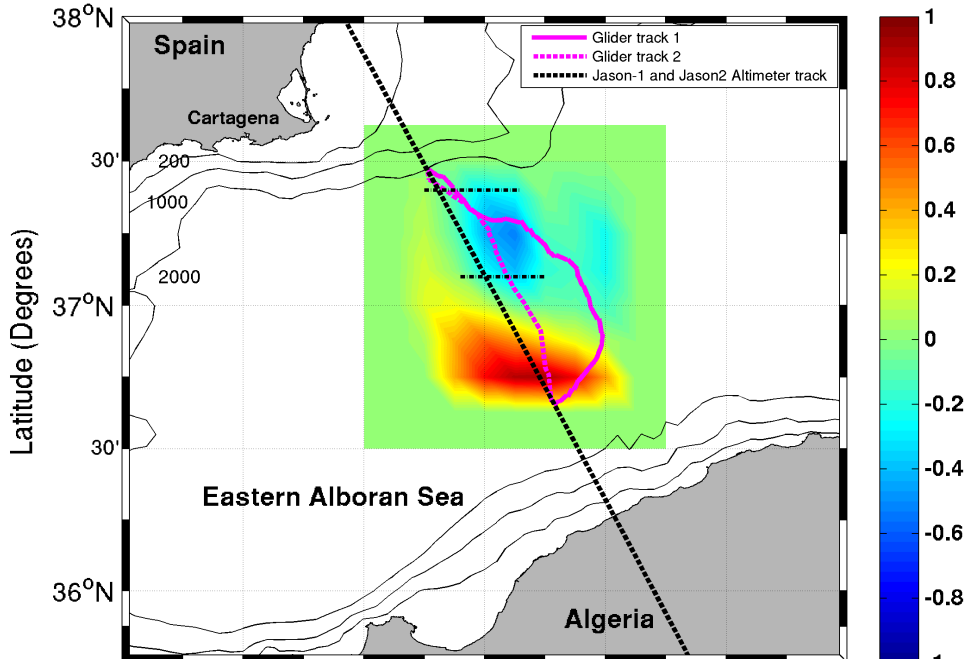
MULTI-SUB project

- Multi-platform (ship-based CTD, water samples, ADCP, gliders and drifters) high-resolution experiments
- Western Mediterranean Sea
- To be merged with French activities for a multiship 2021 campaign

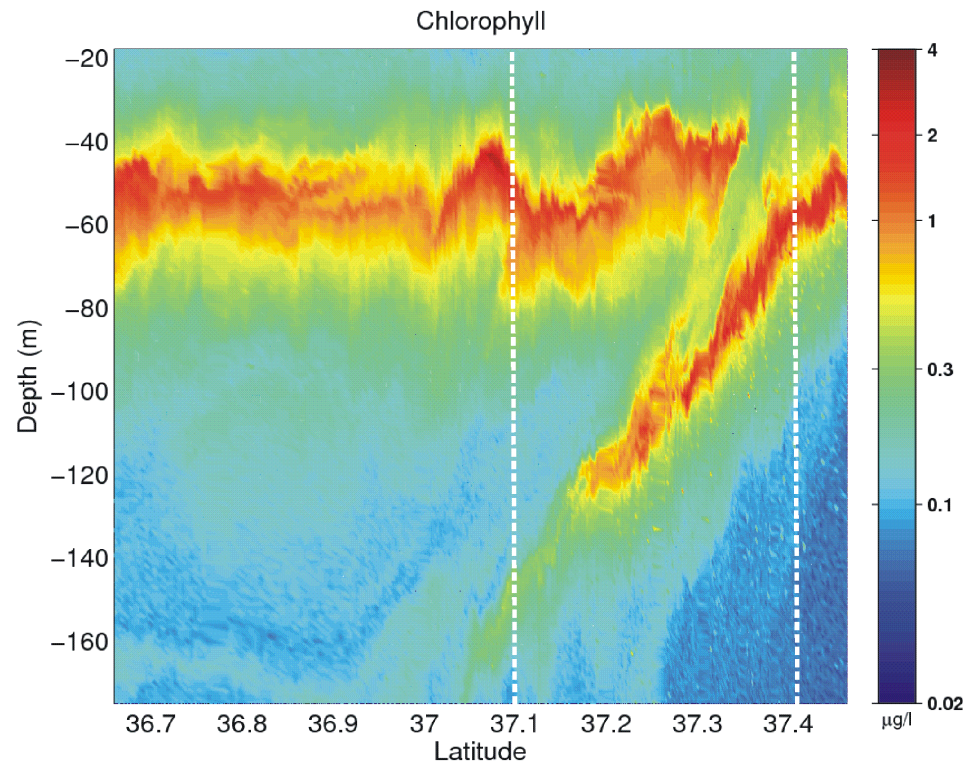
PI: A. Pascual

IMEDEA
CSIC
Consejo Superior de Investigaciones Científicas
UIB
Universitat de les Illes Balears
SOCIB
Balearic Islands Coastal Observing and Forecasting System

Heritage: 2008-2014 ALBOREX campaigns (60 glider missions)



Quasi-geostrophic vertical velocity at 75 m. Units are m day-1.



Ruiz et al GRL 2009

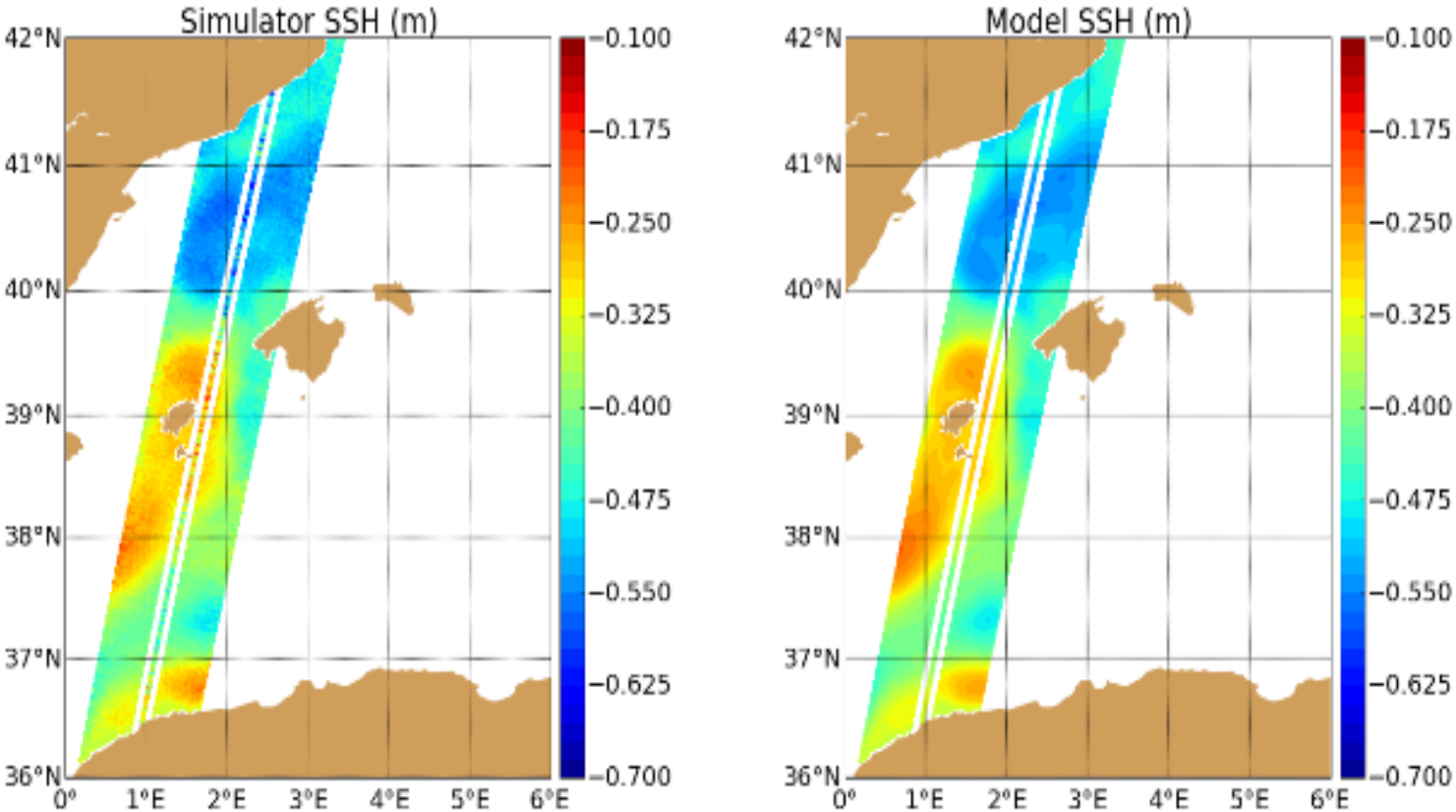
Combination of glider technology and CTD data with altimetry to diagnose vertical velocities and map SSH

The group has strong submesoscale expertise and infrastructure in the region

OBJECTIVE 1

2016:

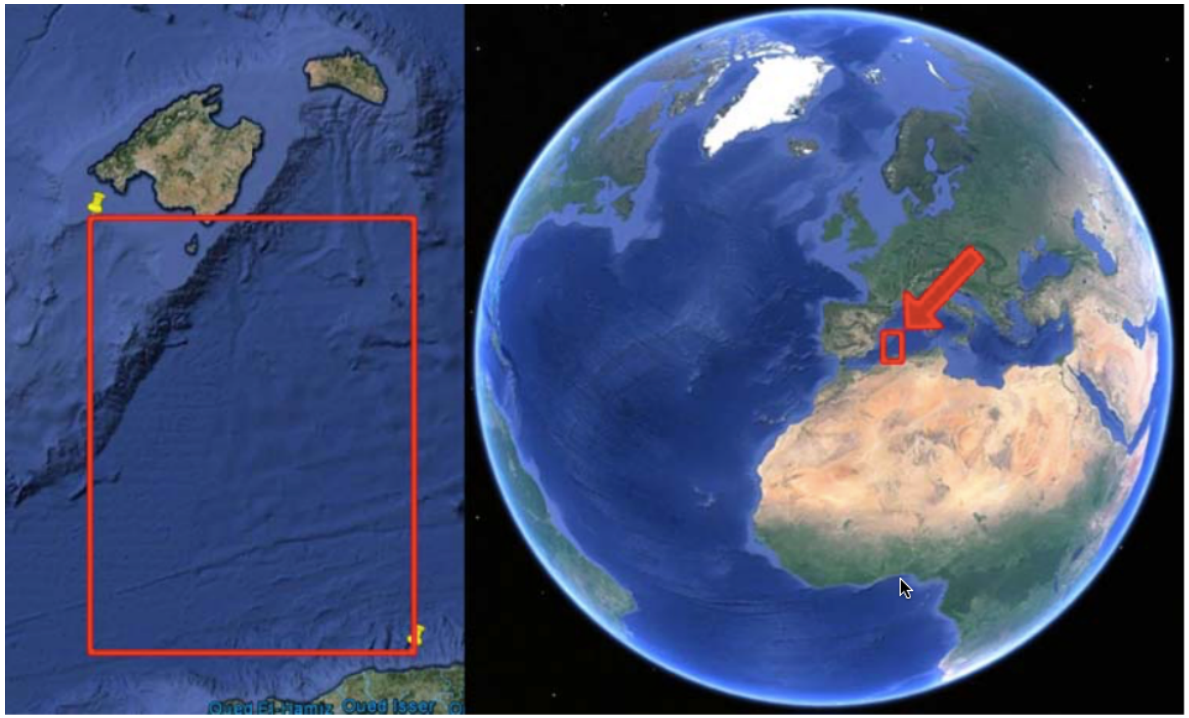
- Study of variability (altimetry reanalysis) in South-Western Med
- SWOT simulator applied to ROMS simulations



SSH (m) pseudo SWOT (left) and SWOT grid interpolated ROMS model data (right) on the 12th of January 2016 (L. Gómez-Navarro et al.)

OBJECTIVE 2 (ongoing)

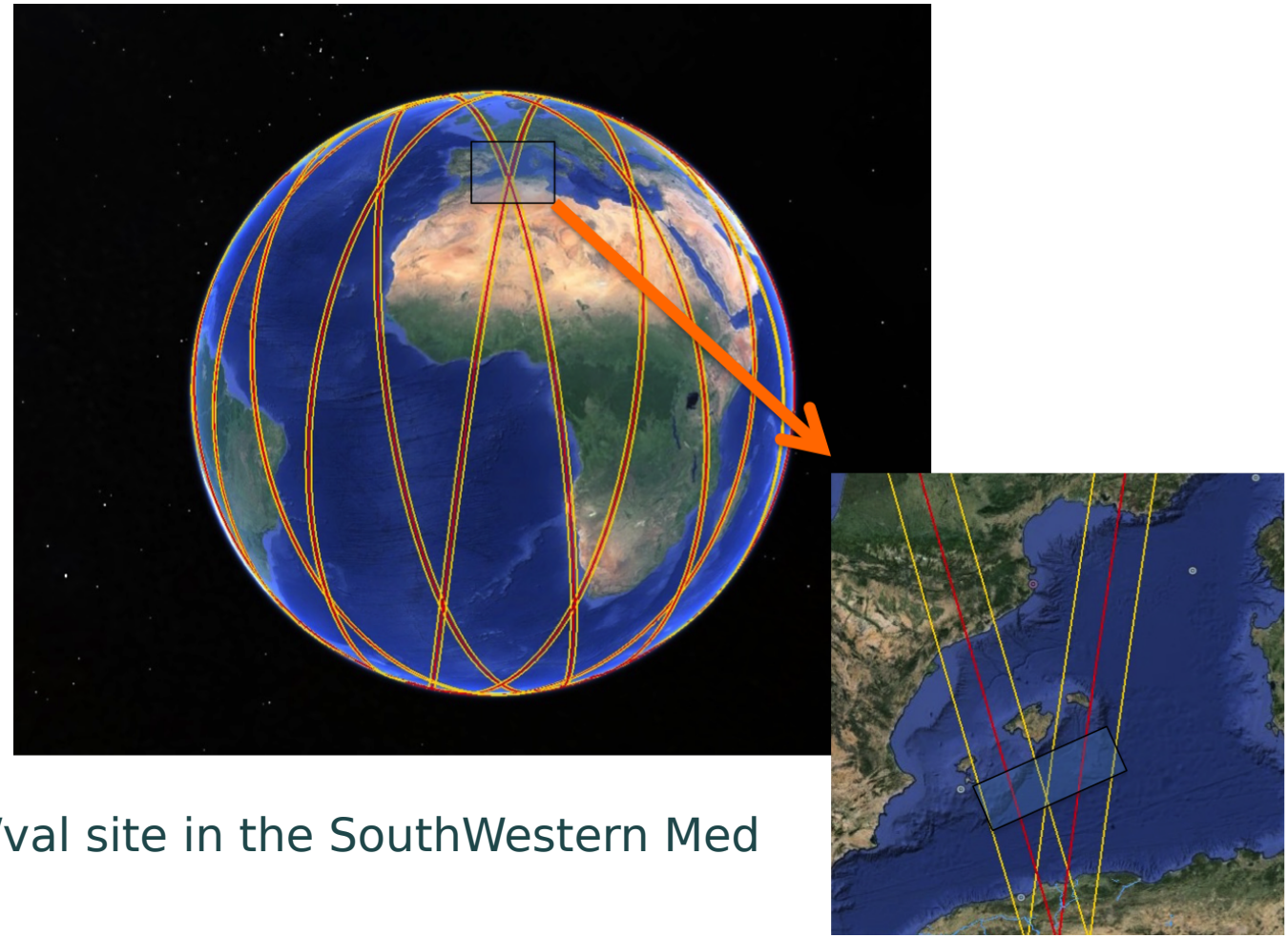
2016-2017: Sentinel-3 along track glider missions + ADCP R/V SOCIB
First mission: 30 May 2016
South-Western Med
(SLTAC-CMEMS – IMEDEA – CLS – SOCIB)



First mission: 30 May 2016
Preliminary glider Waypoint list

OBJECTIVE 3: multiplatform campaign

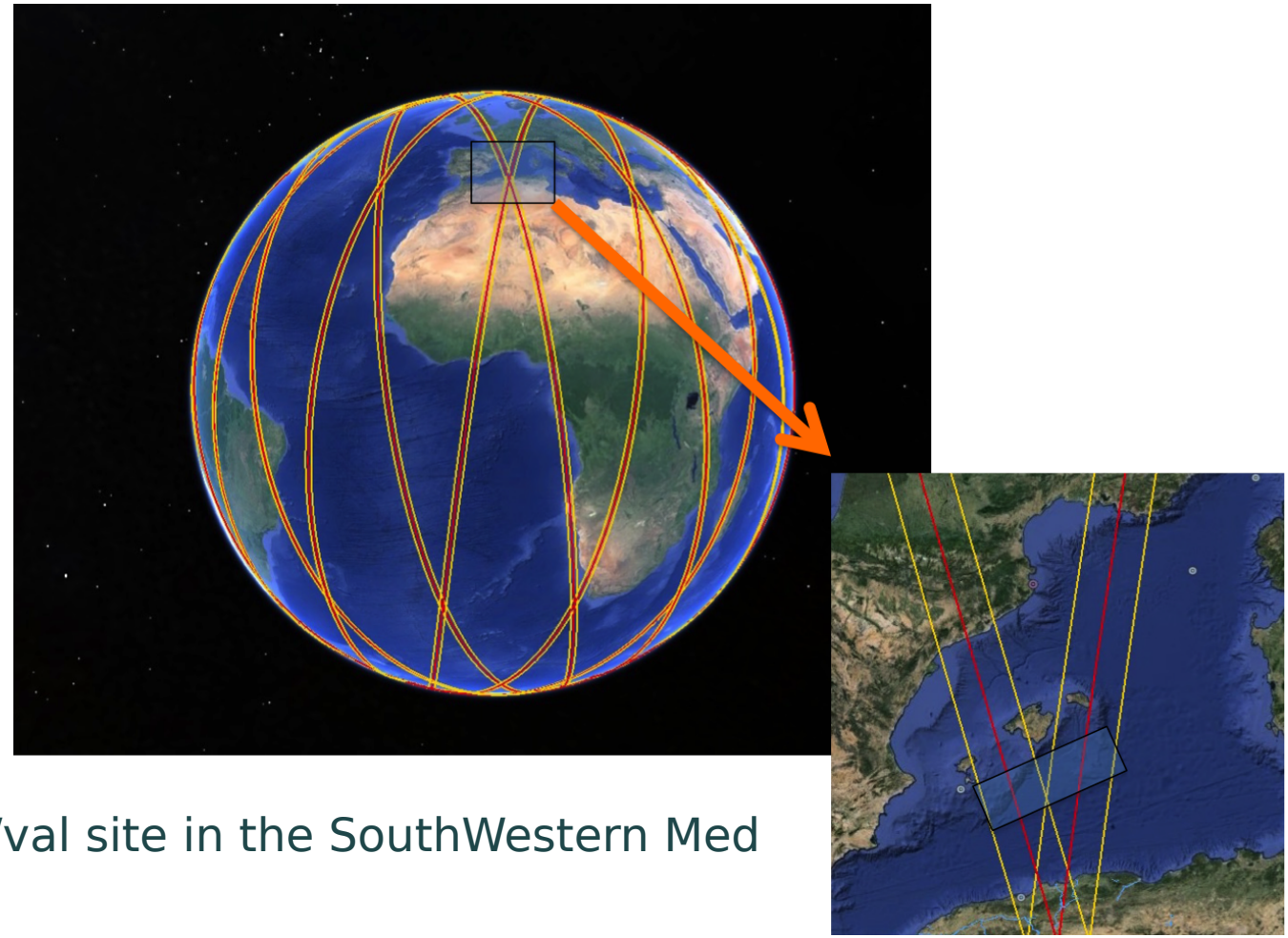
2018: in coordination with BIOSWOT campaign
(funding pending - requested to Spanish Research Program)



SWOT cal/val site in the SouthWestern Med

OBJECTIVE 3

2018: PRE-SWOT multi-platform experiment in coordination with BIOSWOT experiment (funding pending - requested to Spanish Research Program)



SWOT cal/val site in the SouthWestern Med

2021: submesoscale CalVal & process study campaign

BIOSWOT

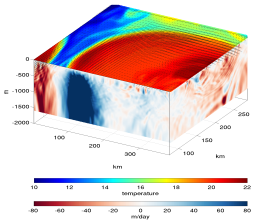
Biophysical applications of SWOT observations

In France
LOCEAN-IPSL
LEGOS
IFREMER
METEOFRANCE
Museum of Natural History
MIO

Partners abroad:
IMEDEA/SOCIB (A. Pascual)
Univ. Washington (P. Gaube)
Plymouth Marine lab (Francesco Nencioli)

Physics

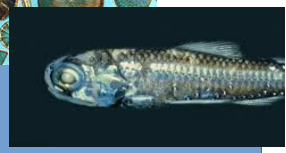
- From SSH to 3D dynamics
- CalVal OSSE



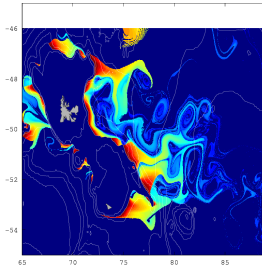
Biogeochemistry

Impact of the fine scales on the fate of anthropogenic carbon

Ecology



High resolution altimetry for:
- Plankton biodiversity
- support to Marine Protected Area design (zoning)



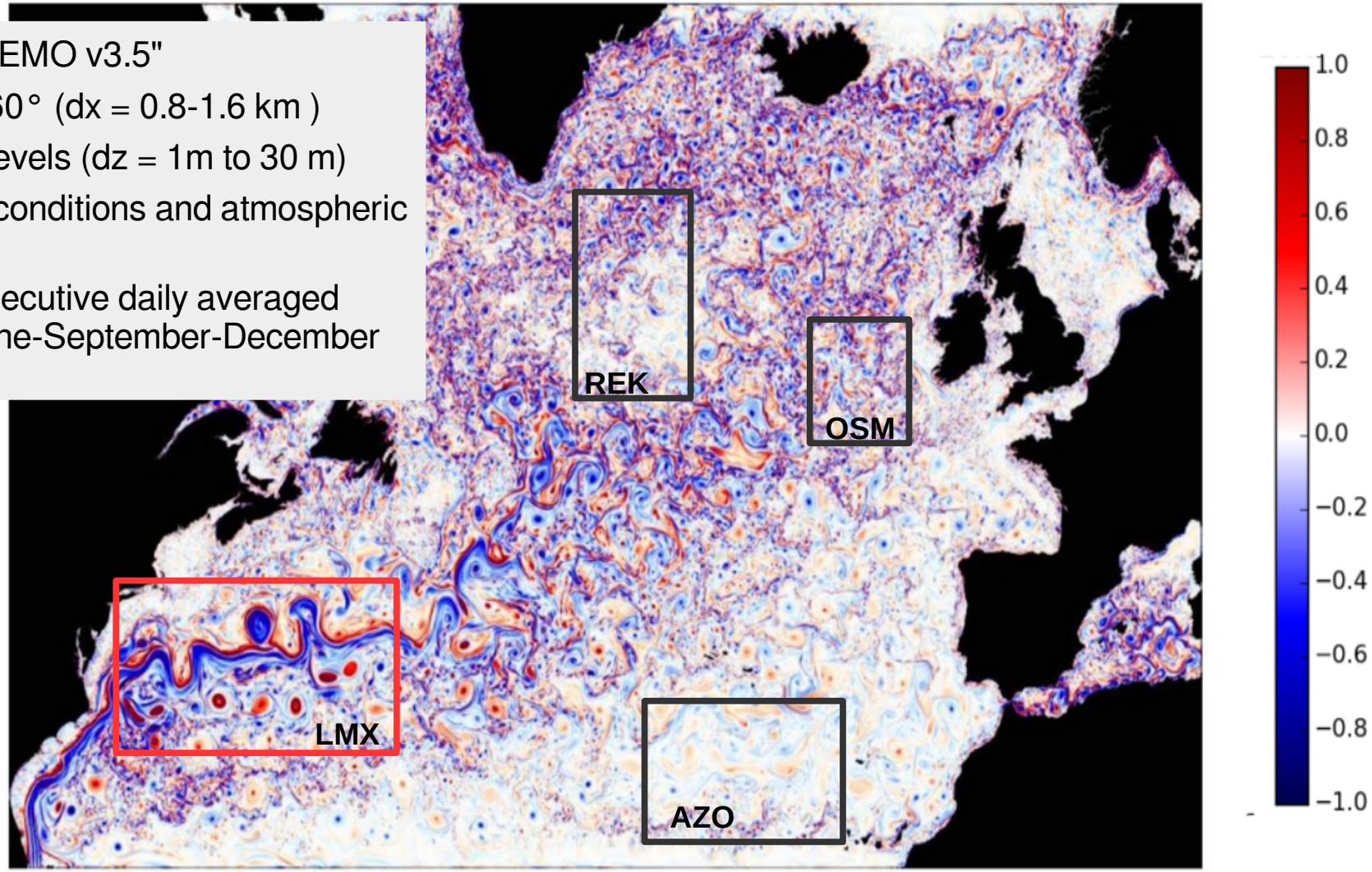
CalVal & process in situ campaigns

- Biophysical experimental competences
- Mediterranean partnerships
- 2021 campaign preparation

BIOSWOT – some model results

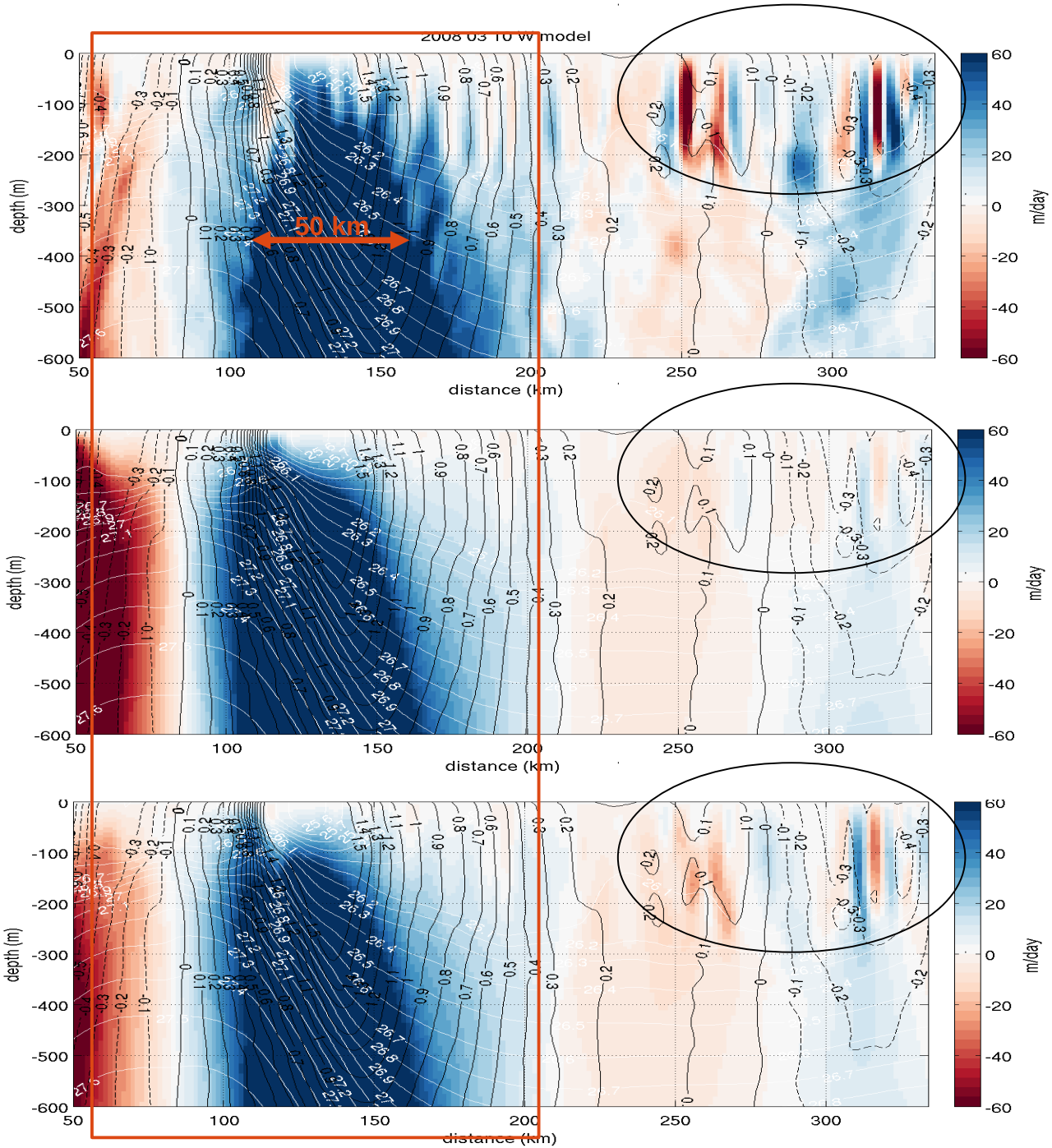
NATL 60 Model configuration and numerical experiment (J. Le Sommer)

- numerical code : NEMO v3.5"
- horizontal grid : 1/60° (dx = 0.8-1.6 km)
- vertical grid : 300 levels (dz = 1m to 30 m)
- realistic boundary conditions and atmospheric forcing
- 4 series of 10 consecutive daily averaged outputs in March-June-September-December



Surface relative vorticity in winter

BIOSWOT – some model results



Vertical velocity in the model
Gulf stream region
10 March 2008

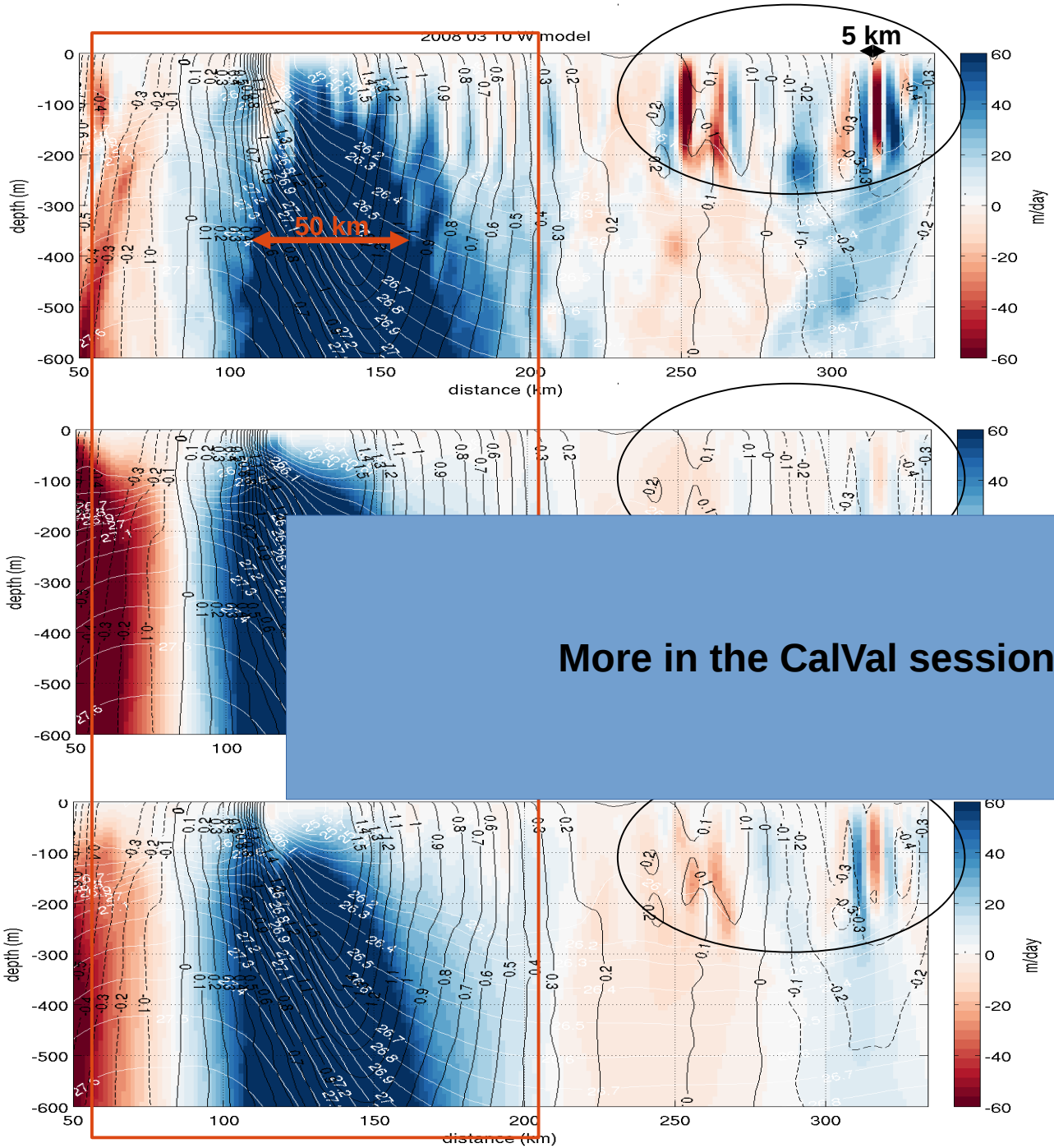
Twg

Vertical velocity from the quasi geostrophic omega equation

TW + AG + FL

Vertial velocity from the omega equation including the ageostrophic field and the windstress

BIOSWOT – some model results



Vertical velocity in the model
Gulf stream region
10 March 2008

More in the CalVal session

city from the
ophic omega

TW + AG + FL

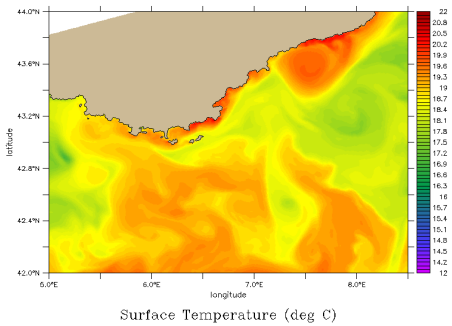
Vertial velocity from the omega equation including the ageostrophic field and the windstress

2015 OSCAHR campaign (A. Doglioli)

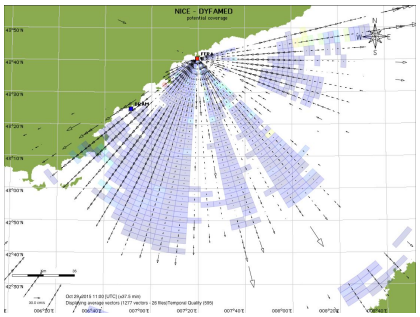
Developping fine-scale biophysical competences

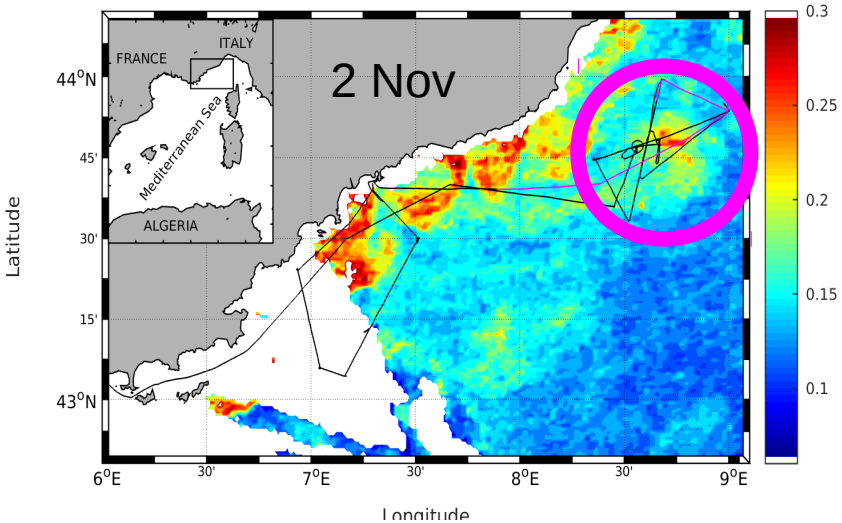
Explore the link between fine-scale physics and phytoplankton diversity

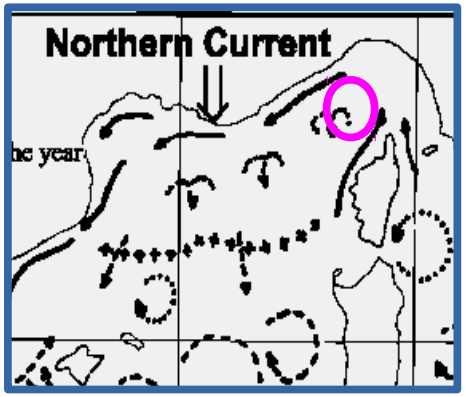
SYMPHONIE & MARS3D-ECO3M



HF radar



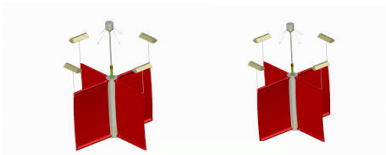


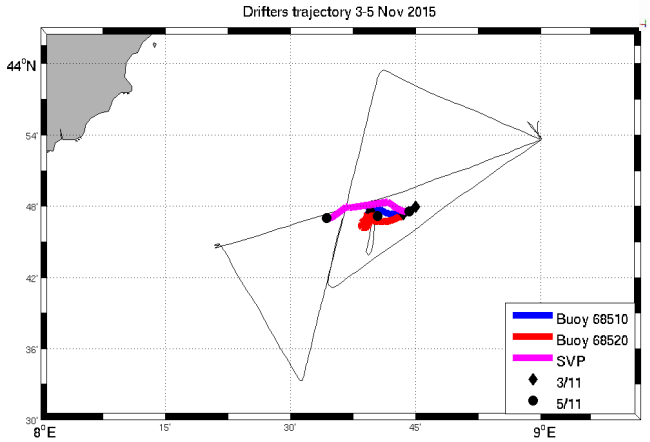


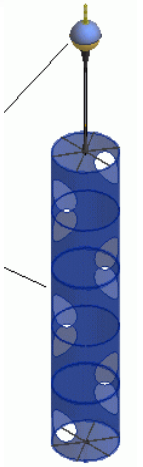
Millot 1998

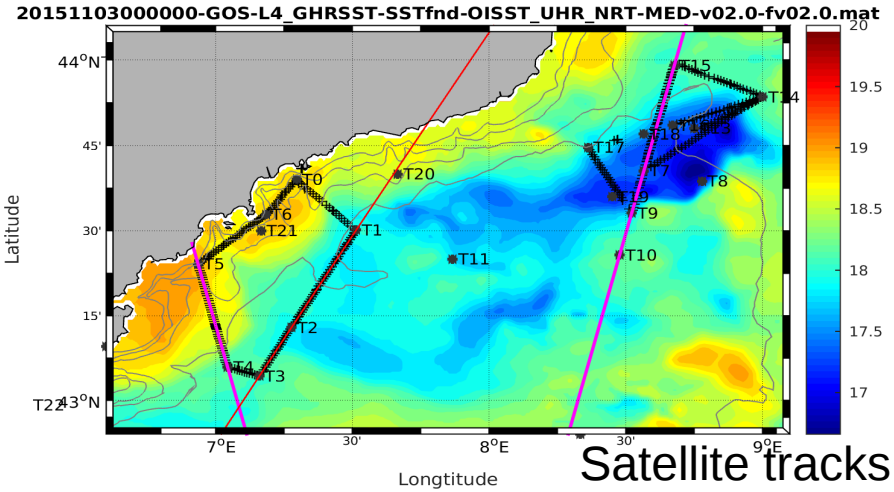
Lagrangian drifters

2 code and 1 SVP







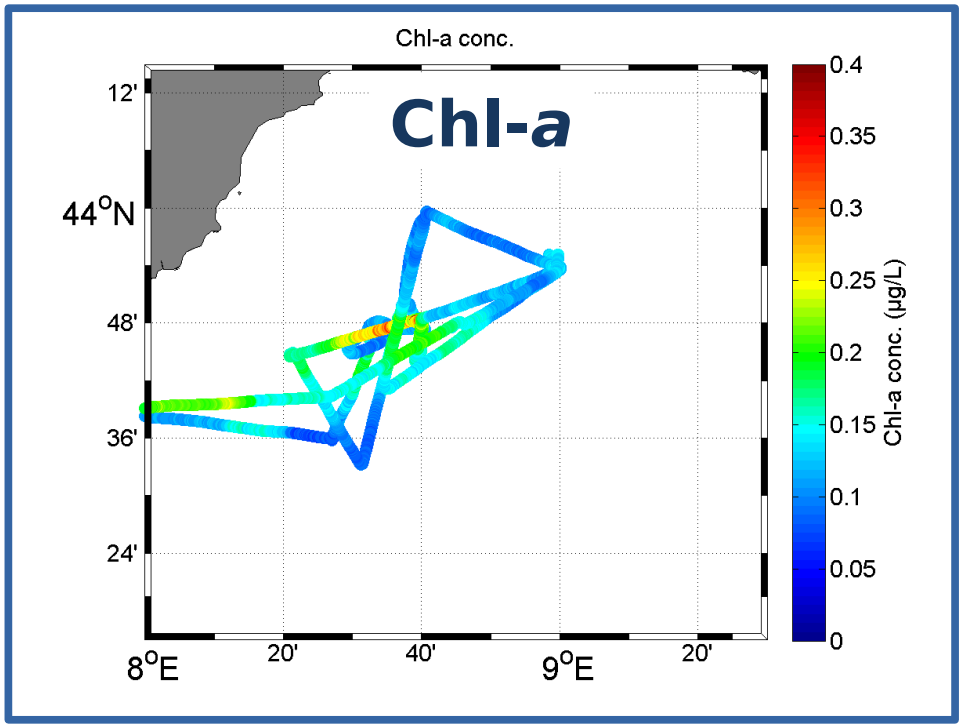


Satellite tracks

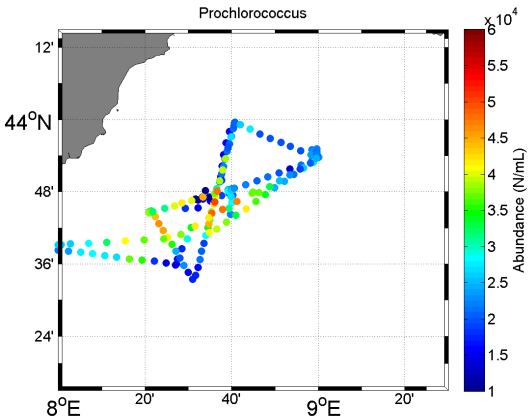
SaralAltiKa & Jason2

BIOSWOT – some experimental results

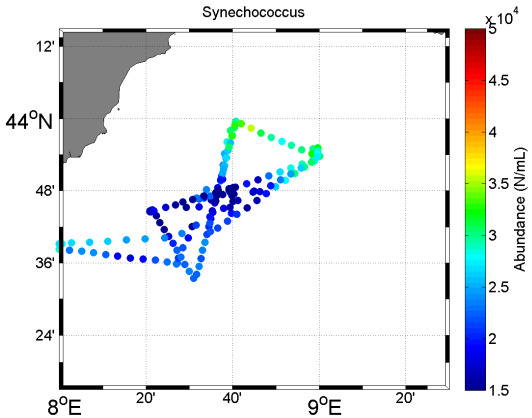
Underway cytometry + 7 fixed stations



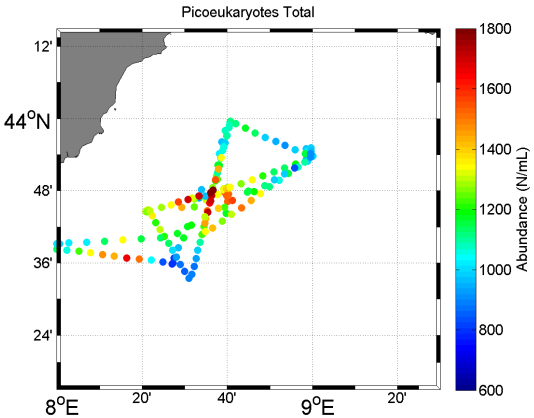
Prochlorococcus



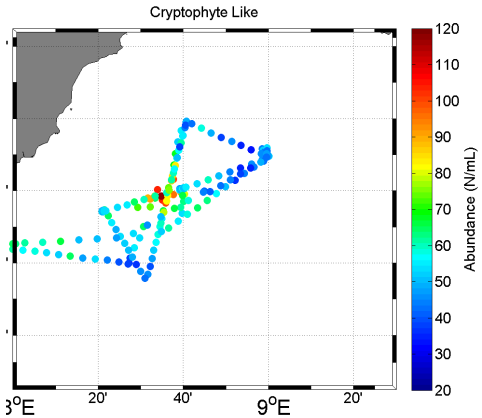
Synechococcus



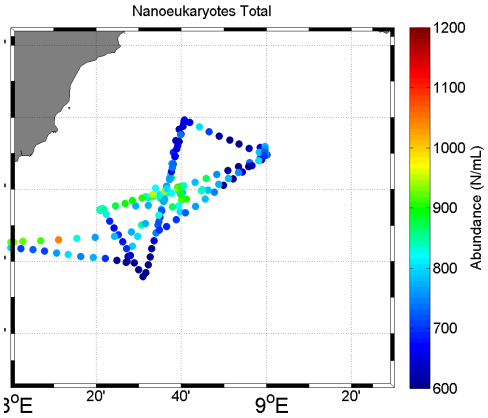
Pico-



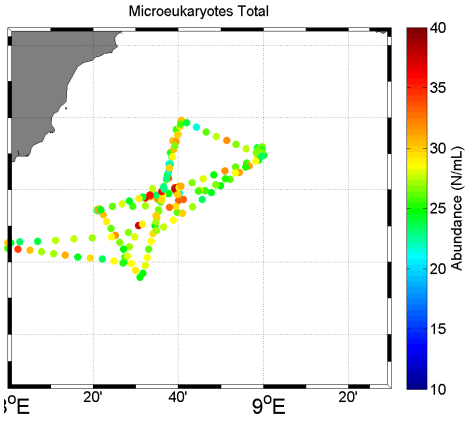
Cryptophytes



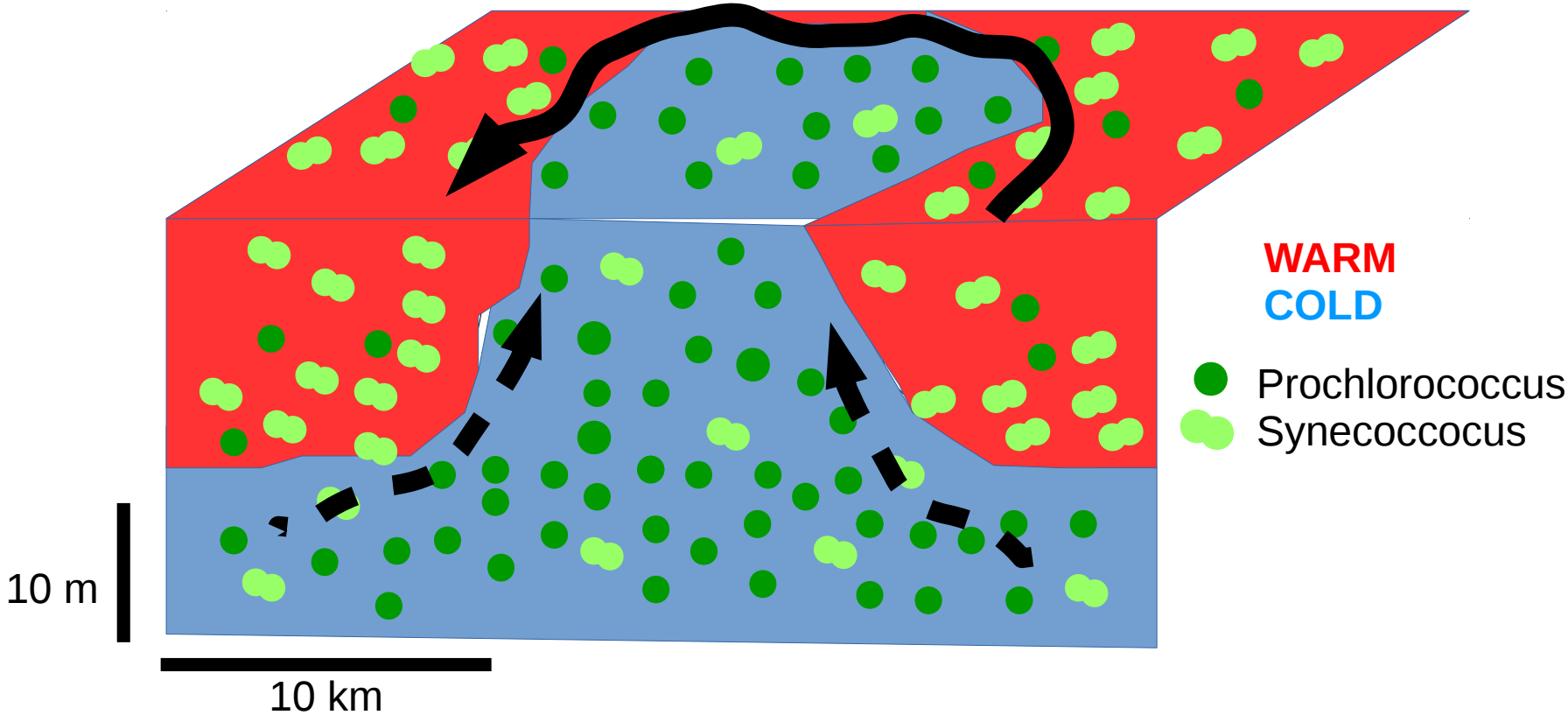
Nano-



Micro-



OSCAHR campaign: Emerging biophysical picture



Preliminary conclusion:

SWOT-scale variability inherited by planktonic diversity through niche partitioning

Promising result for the use of SWOT maps to guide and interpret biodiversity studies

Competences be used in the 2021 Mediterranean campaign in collaboration with MULTI-SUB

Thank you!