# (Sub) Mesoscale characterization from multi-platform experiments: anticipating SWOT launch

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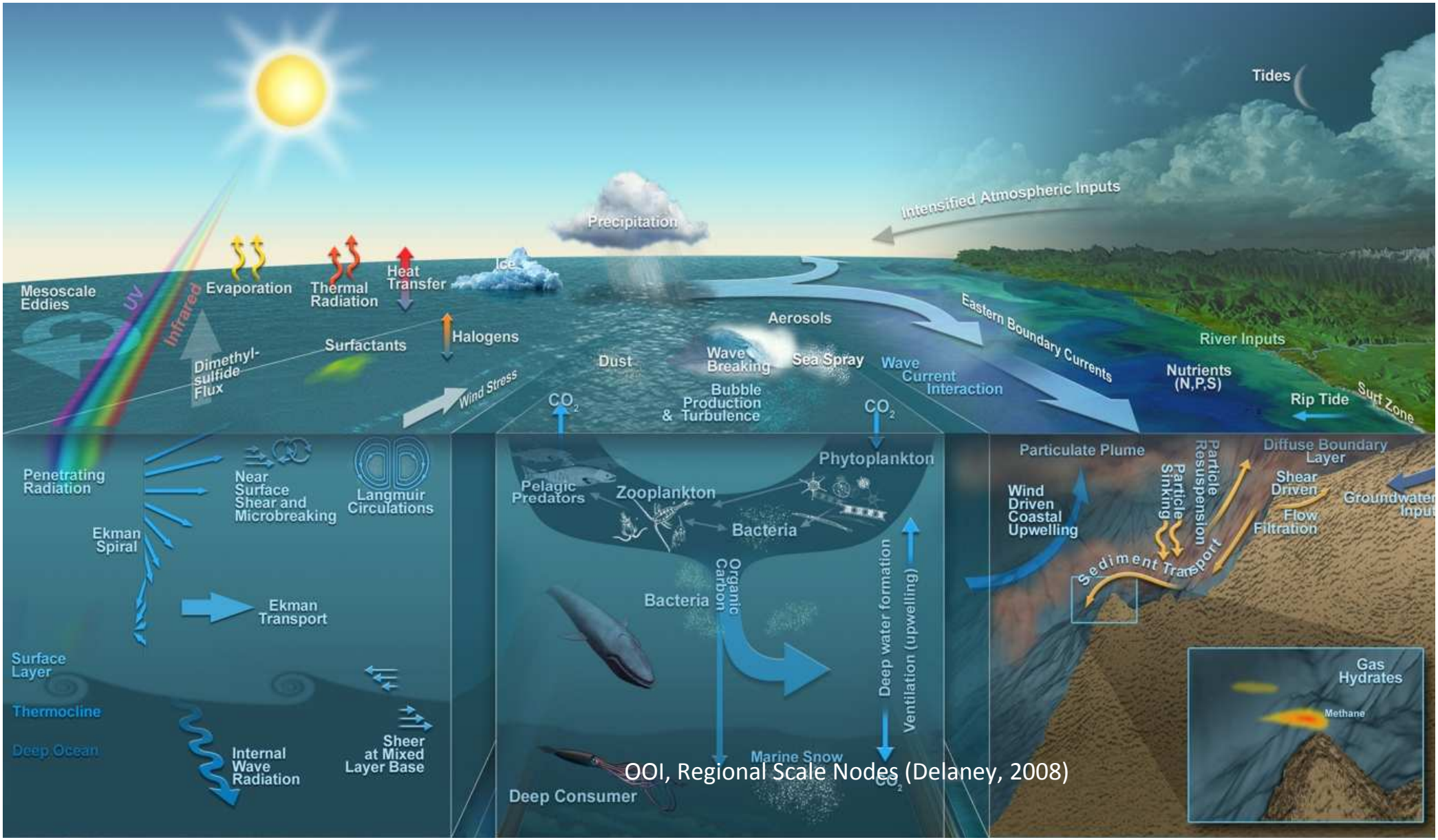
IMEDEA(CSIC-UIB)

With inputs from G. Valladeau, A. Ollivier, F. D'Ovidio, P. Bonnefond, N. Picot, J. Tintoré, S. Ruiz, L. Gómez-Navarro, A. Sánchez-Román, Y. Faugère, I. Pujol, F. Durand, R. Morrow and others

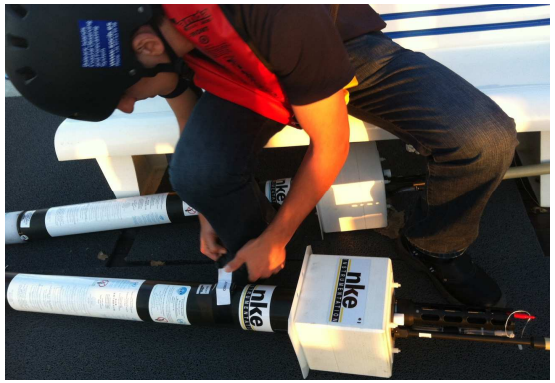
**From: single scientist / single process studies… (still needed!)**
**To: joint observing systems of our oceans & interactions**

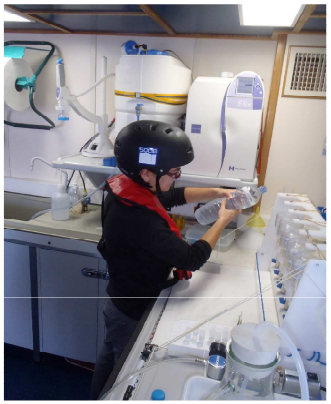


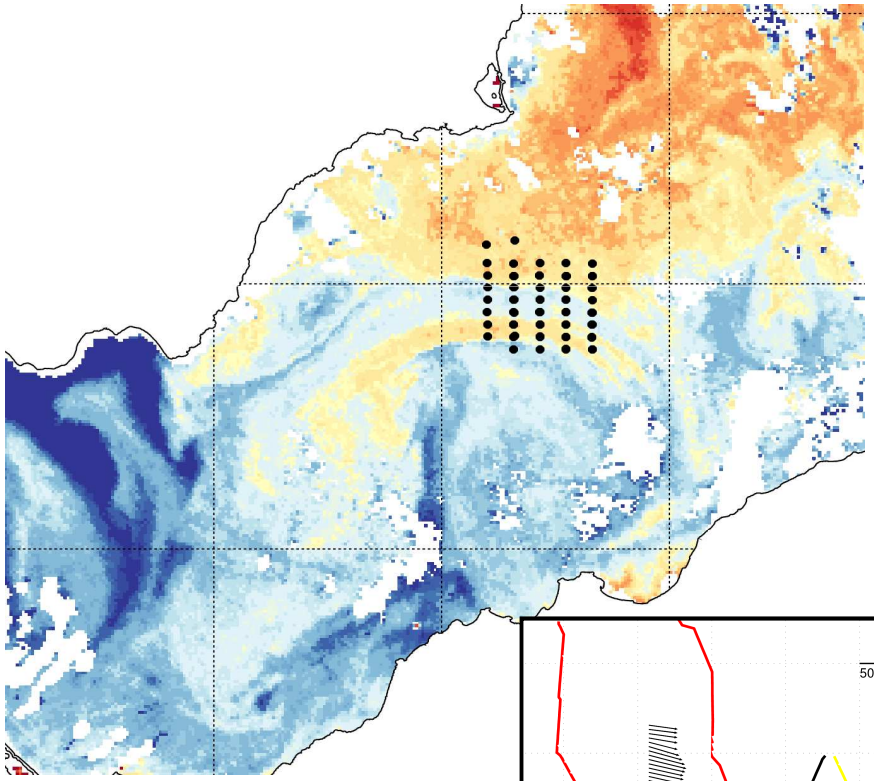

OOI, Regional Scale Nodes (Delaney, 2008)

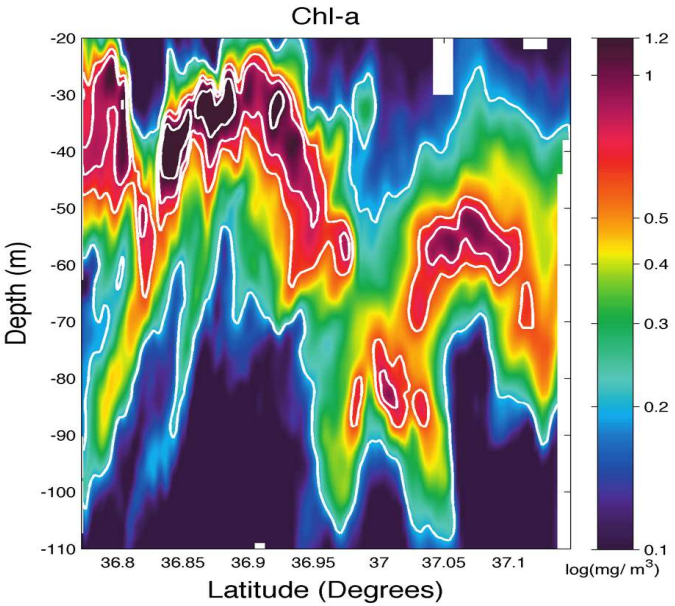
# Integrated Multi-Platform Approach

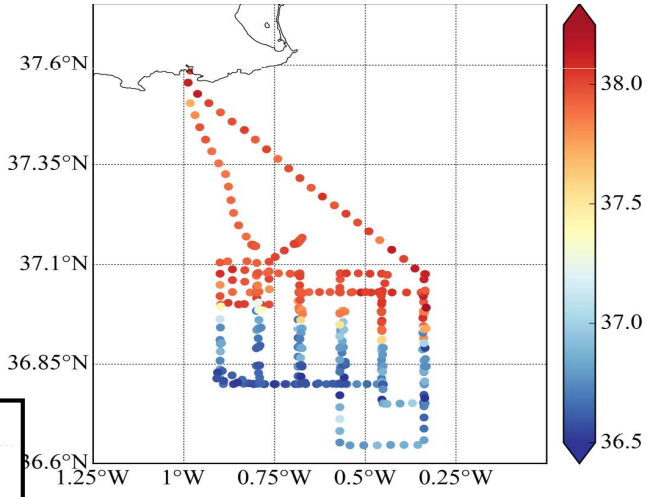
Bouffard et al. (2010, 2012), Escudier et al. (2013, 2016); Juza et al. (2016); Marcos et al. (2015); Morrow et al. (2016); Ruiz et al. (2009a,b, 2012, 2015); Pascual et al. (2010, 2013, 2015); Tintoré et al. (2013); Troupin et al. (2015)

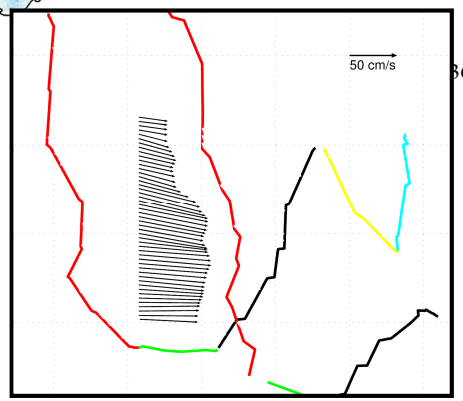









# ALBOREX

Meso and submesoscale processes

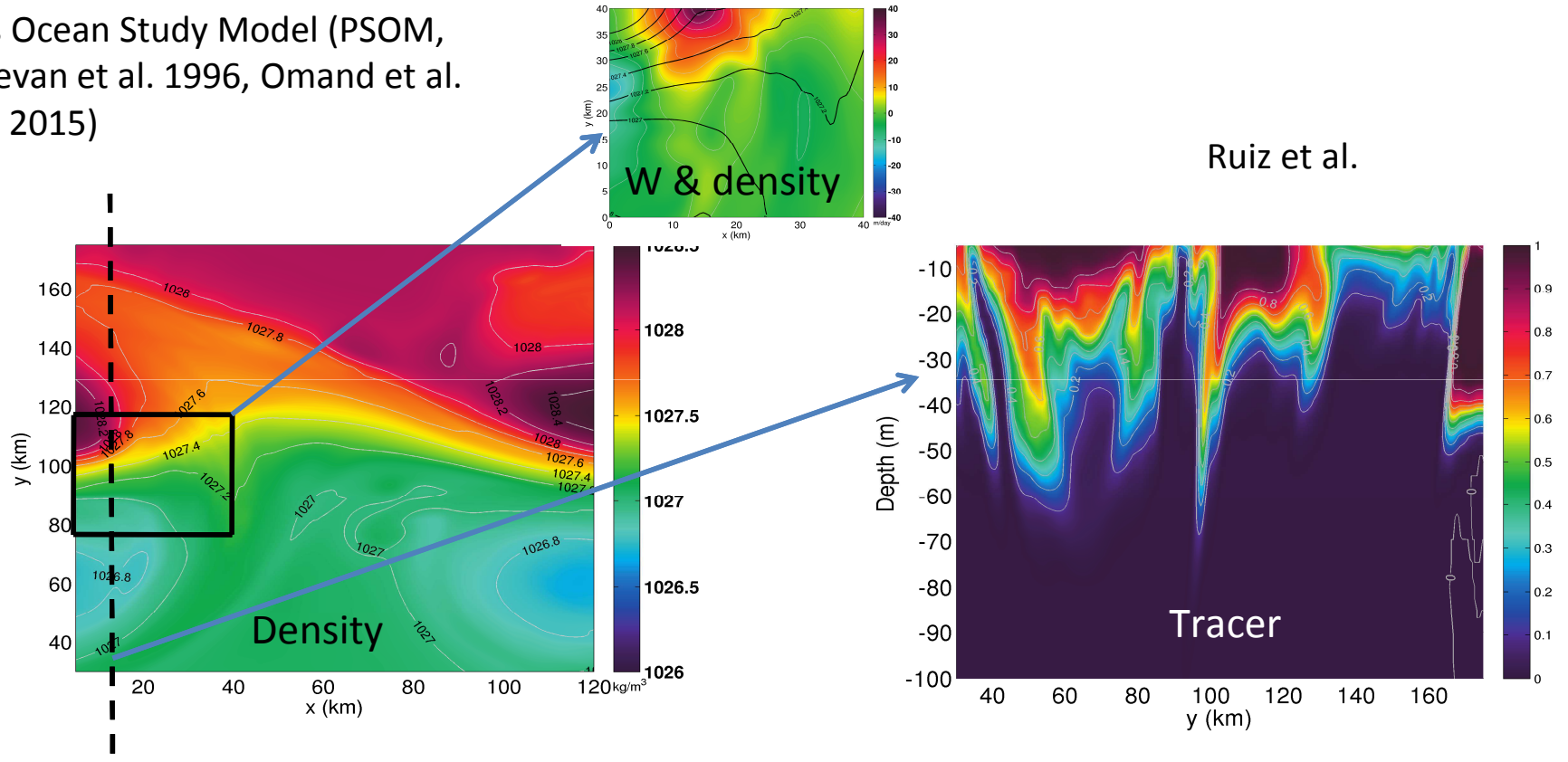
# Observations complemented with numerical simulations

## Potential mechanisms of vertical motion

Process Ocean Study Model (PSOM, Mahadevan et al. 1996, Omand et al. Science 2015)

**ALBOREX**

Ruiz et al.




- Vertical velocities of about 45 m/day (x3 w diagnosed by mesoscale QG)
- Modelling results support that front can trigger submesocale dynamics.
- Vertical velocities associated with these submesoscales structures can explain subductions observed by gliders in regions where frontogenesis occurs.

# Anticipating SWOT launch

**Objectives**:

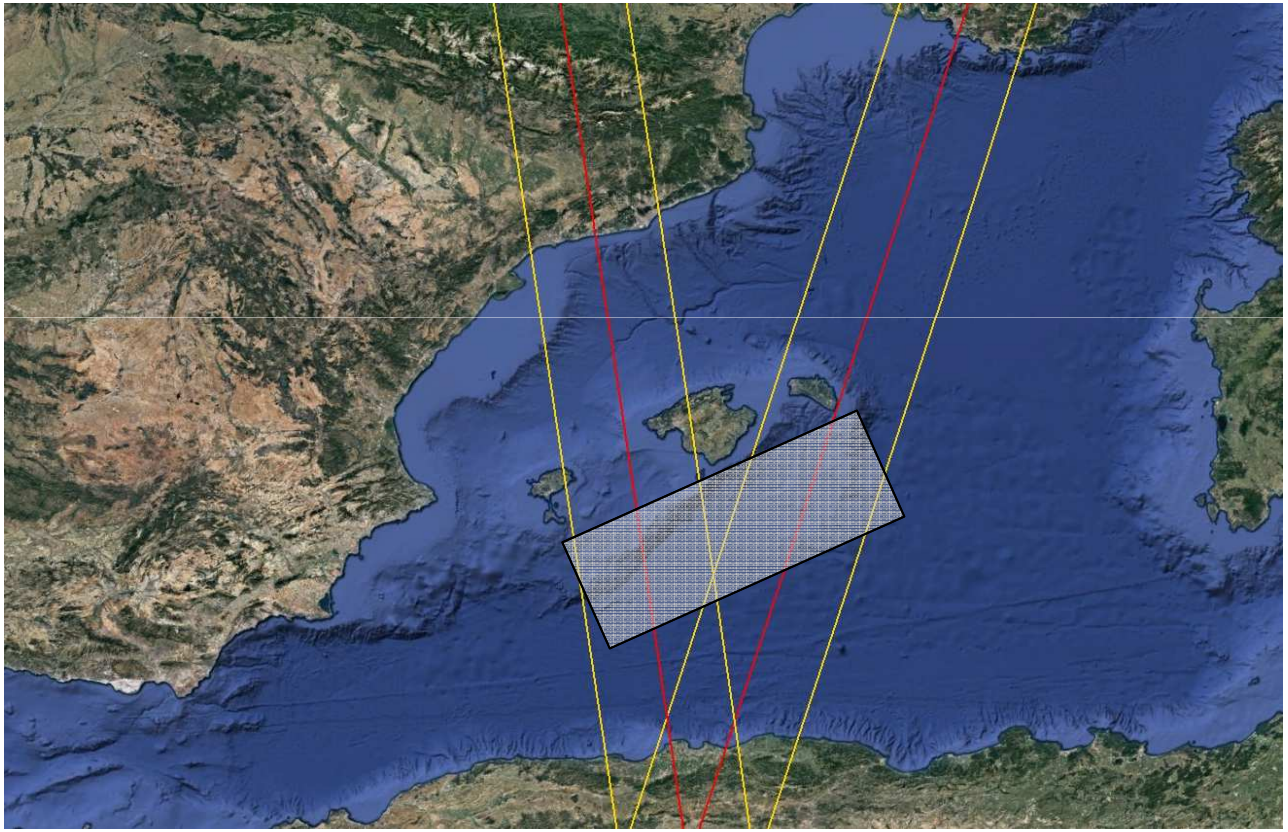
- Contribute to SWOT CAL/VAL and ST
- Improve understanding of meso and submesoscale processes and impacts on biogeochemistry

# Anticipating SWOT launch

GOBIERNO DE ESPANA
MINISTERIO DE ECONOMIA Y COMPETITIVIDAD

## PRE-SWOT multi-platform experiment (2018)

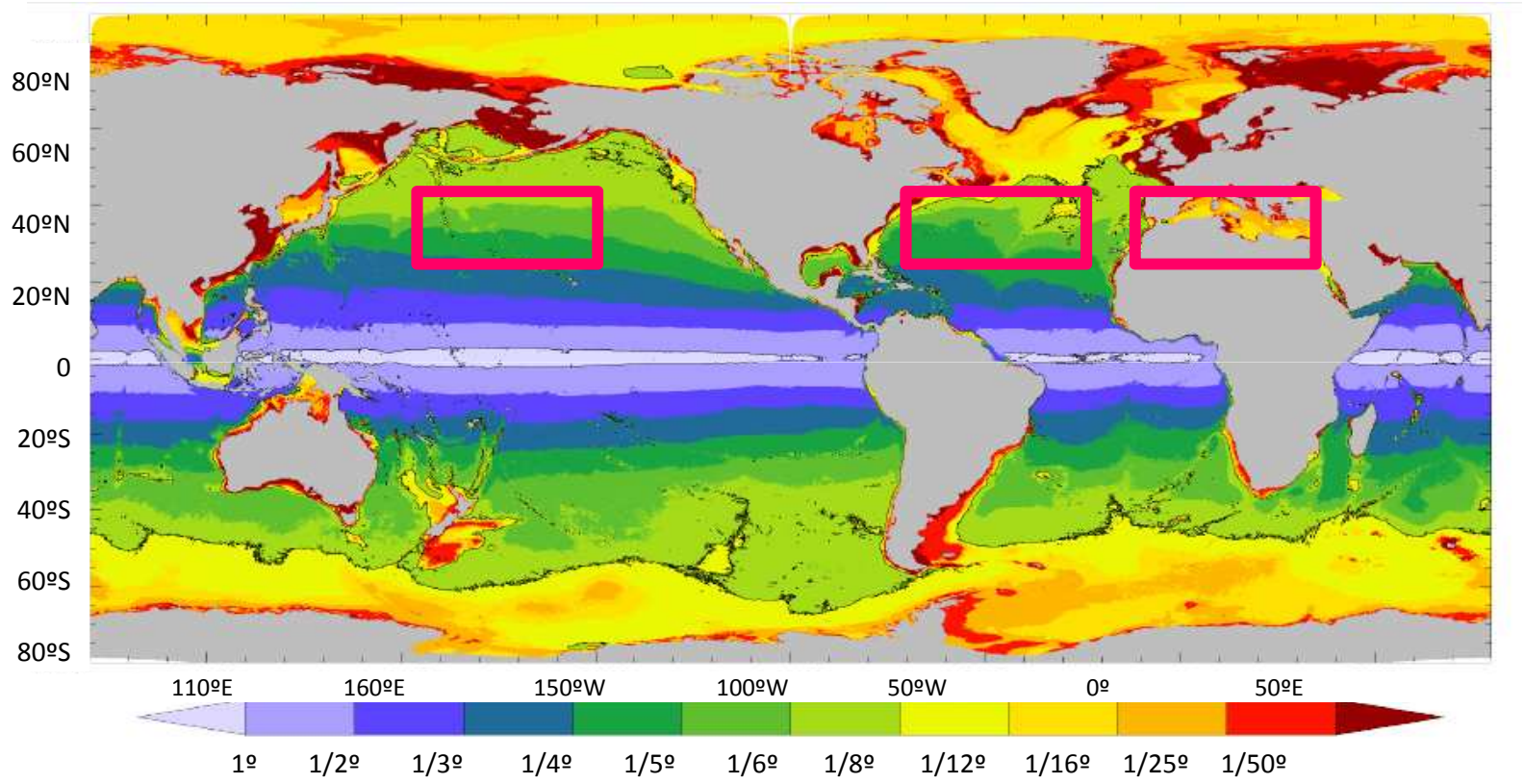
- 'Pocket sized' study region for quantification of the dynamic ocean exchange mechanisms



- Area relatively sparsely sampled in previous oceanographic cruises
- Few modeling and remote sensing studies.
- Small Rossby radius
- Hotspot of biodiversity (bluefin tuna spawning area)
- Low tides
- Low internal waves

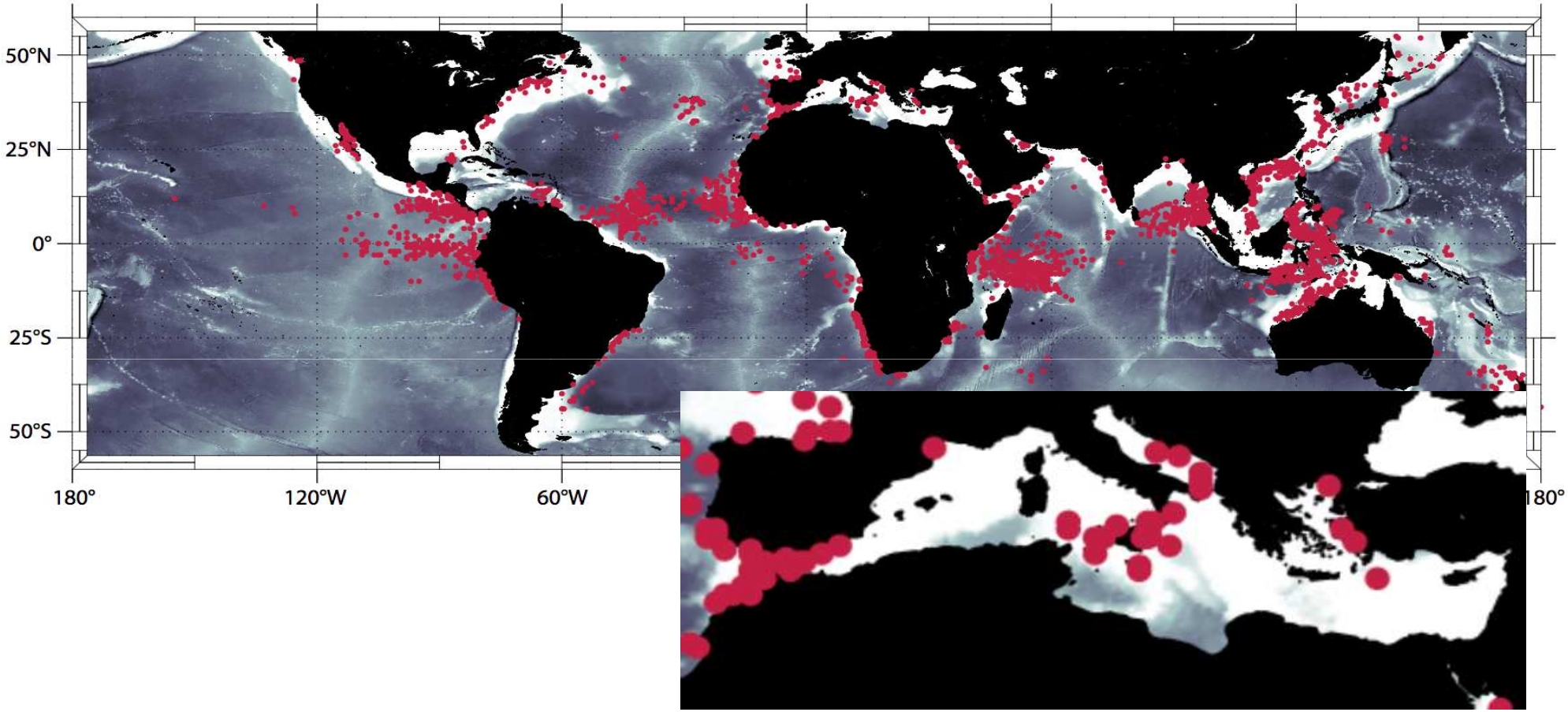
Fast-phase SWOT swaths and area of study to be covered during PRE-SWOT cruise. Funding provisionally confirmed (Spanish Research Program) + BIO-SWOT (CNES)

# Smaller structures in the Mediterranean Sea



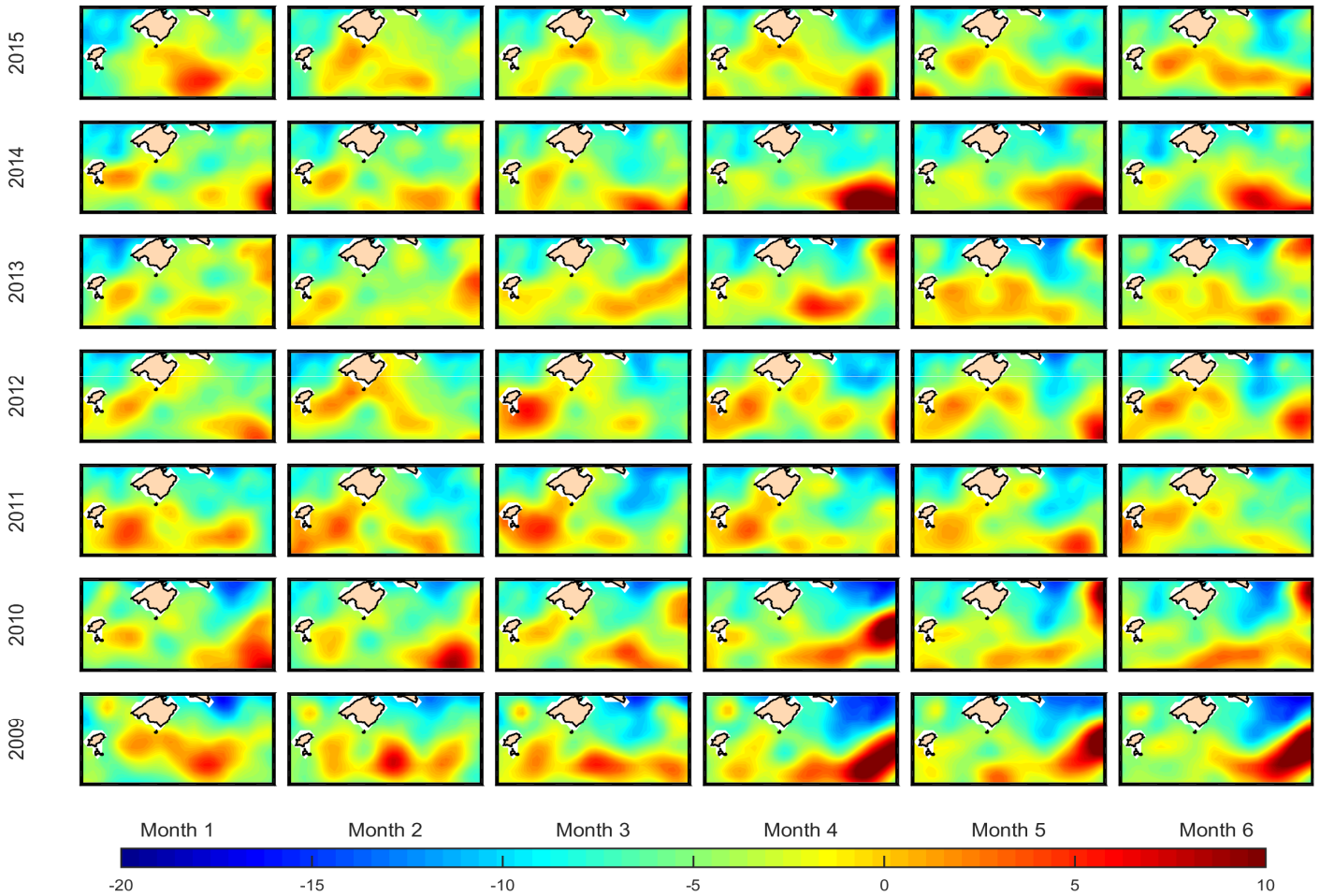

Horizontal resolution needed to resolve the 1st baroclinic deformation radius (Hallberg, 2013)

# Low nonlinear internal waves




Location of nonlinear internal waves observed in 250 m resolution MODIS satellite sunglint imagery acquired from August 2002 through May 2004 (Jackson et al. 2012)

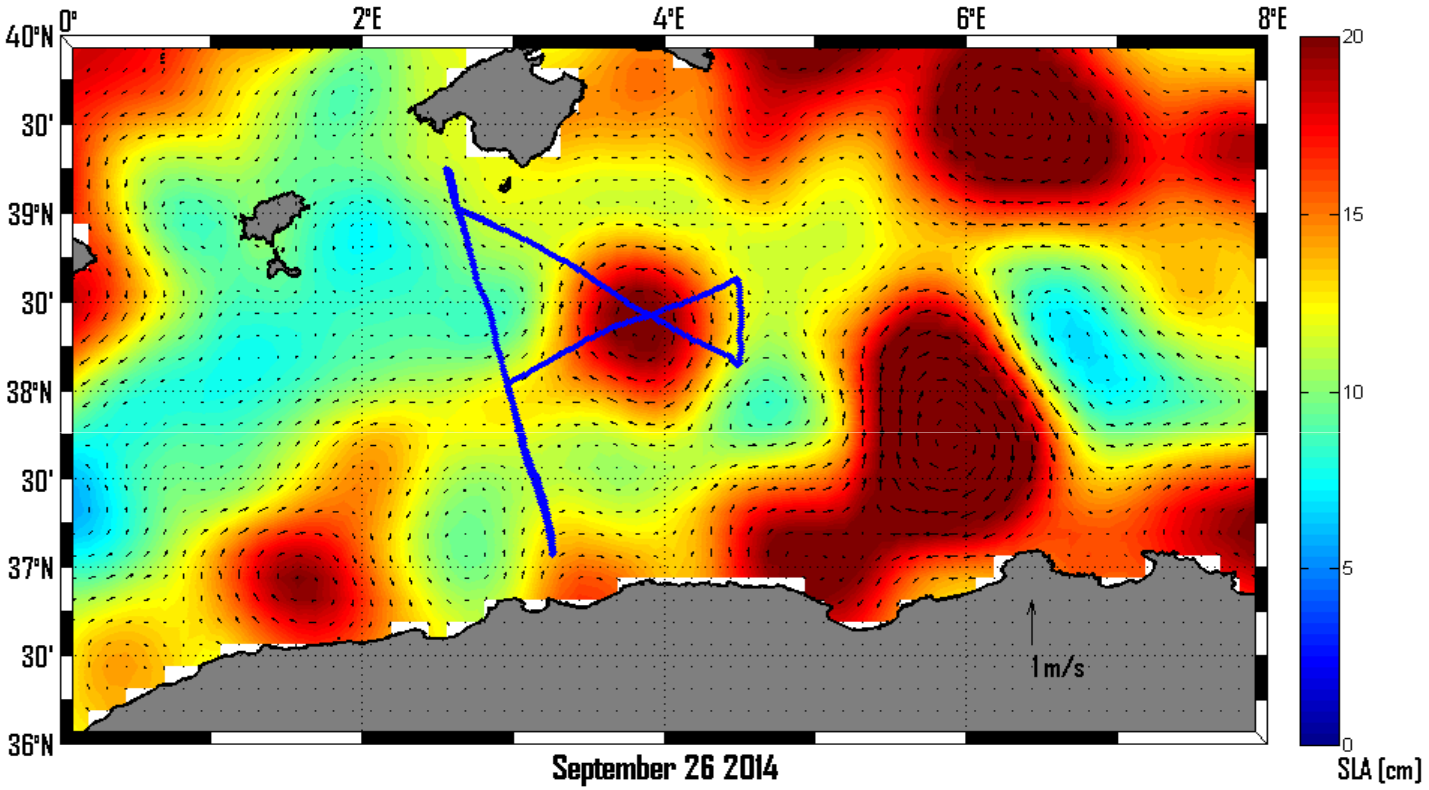
# Anticipating SWOT launch: characterization of the area of study




Monthly ADT means (CMEMS altimetric data)

Gómez-Navarro et al. (2016)

# Anticipating SWOT launch: characterization of the area of study



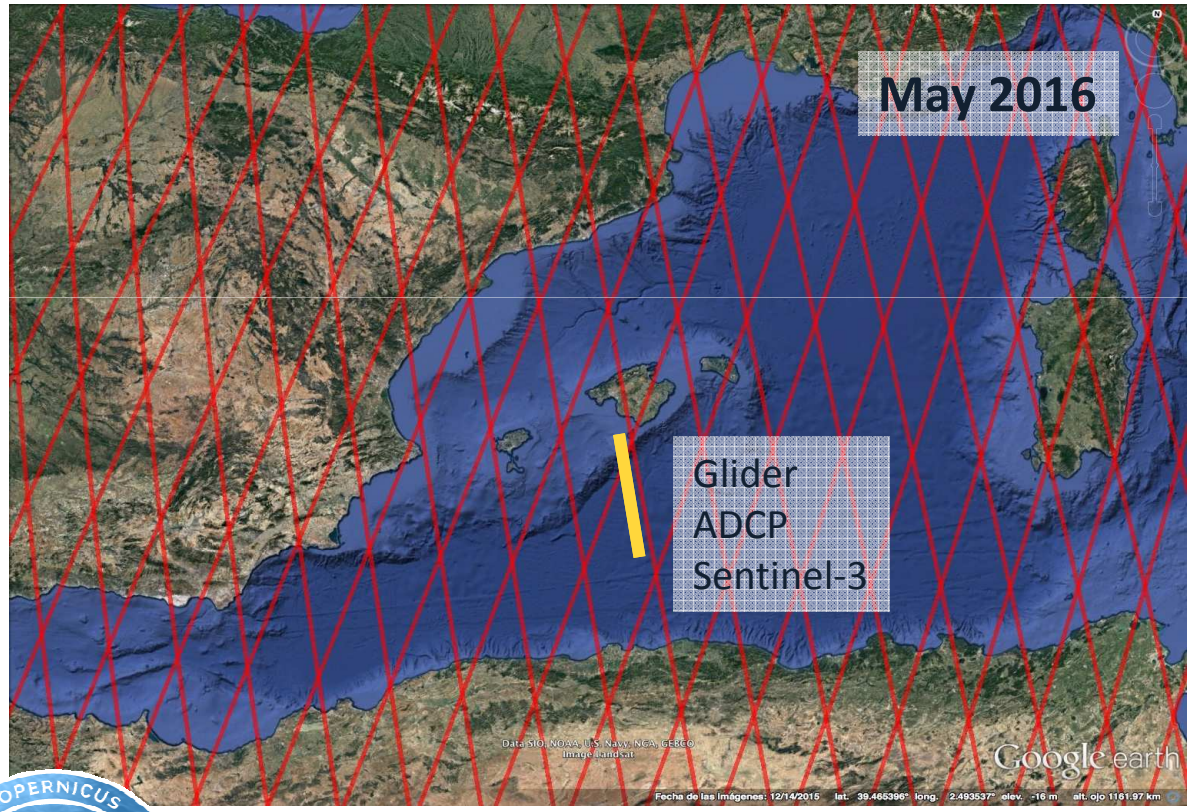

Sea Level Anomaly (color scale)
Geostrophic velocity anomalies (black arrows)

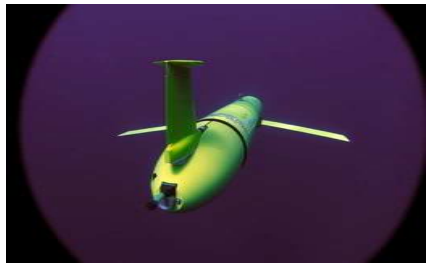
Blue lines show the glider track from 15th Sept to 20th Oct 2014.
The glider sampled and eddy and followed a SARAL/AltiKa track.

Cotroneo et al. (2016)
Gómez-Navarro et al. (2016)
Aulicino et al. In prep.

# Anticipating SWOT launch: characterization of the area of study

## Multi-platform experiment along a Sentinel-3 track



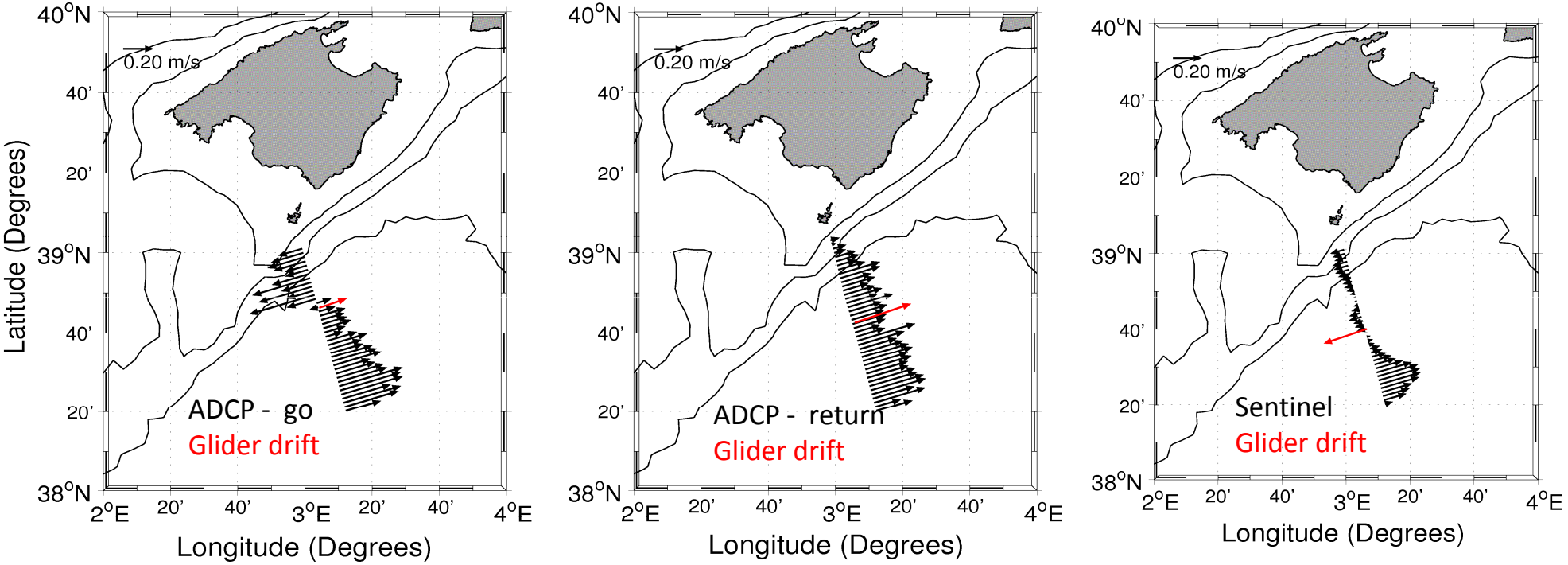
CMEMS SEA LEVEL TAC
Contract SEA LEVEL - TAC Until April 30 2018

IMEDEA · CSIC · Universitat de les Illes Balears

SOCIB Balearic Islands Coastal Observing and Forecasting System

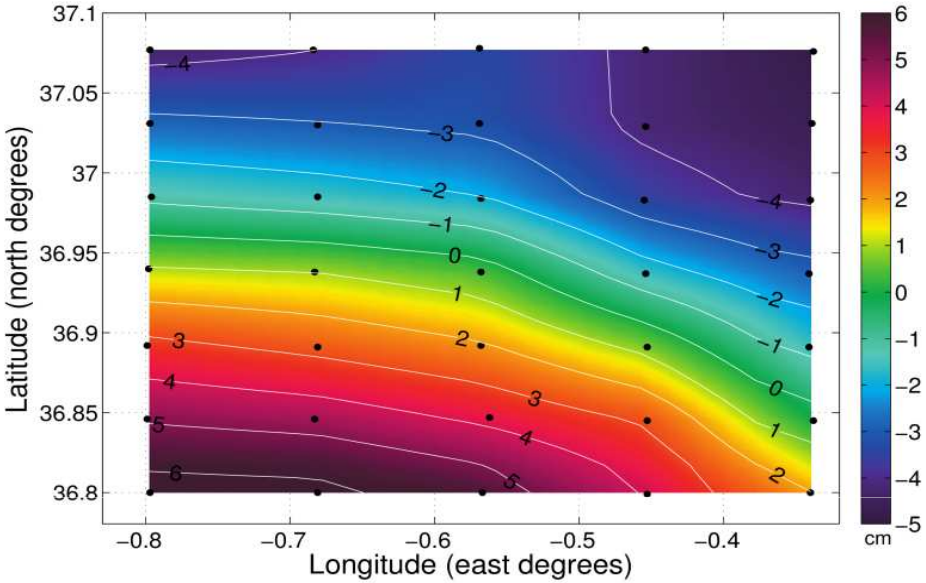
CLS

# Multisensor experiment along a Sentinel-3 track May 2016

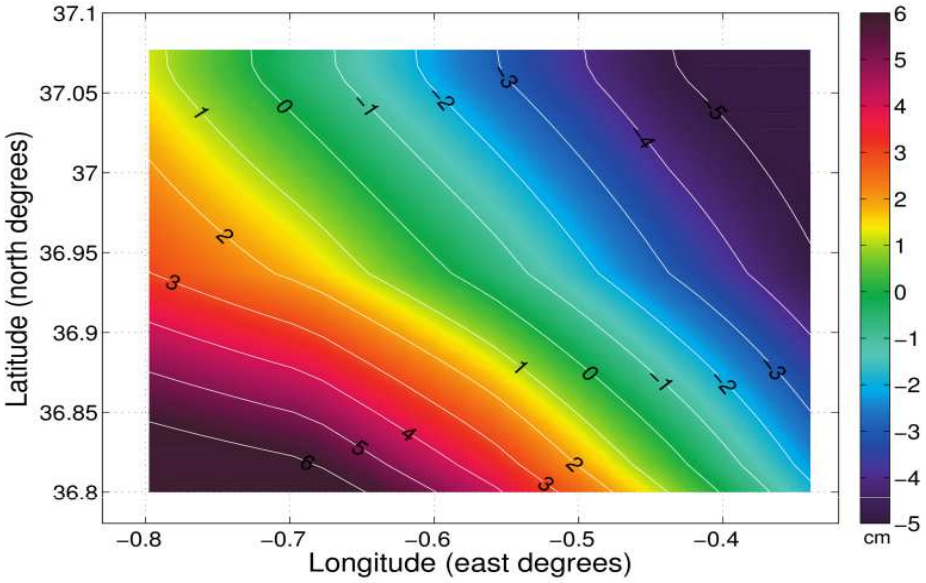



- Multisensor intercomparison allows investigation of different processes (inertial oscillations, wind effect, geostrophic currents, barotropic component…). See details in poster Sánchez-Román et al.
- More campaigns foreseen (next: Nov 2016 – in 10 days)

# DH vs ADT- (2D) – 50x50 km grid




Surface Dynamic height (DH) from ALBOREX (CTD) 24-26 May 2014




Absolute Dynamic Topography (ADT) from experimental CLS-CMEMS product

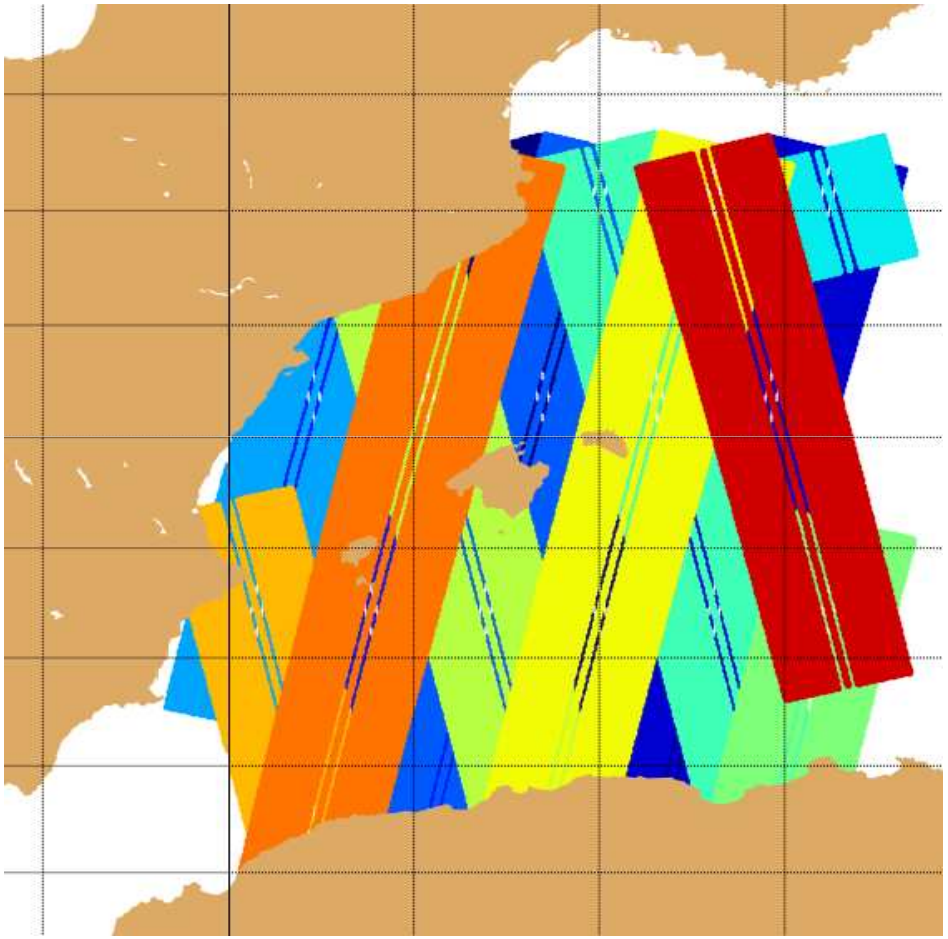
- Good agreement
- New CLS/CMEMS product improves statistics
- Correct front location
- Small scales not resolved

Rmsdiff: 1.82 cm
Corr: 0.83
Var DH: 9.25 cm2
Var ADT: 9.82 cm2

# Anticipating SWOT launch: characterization of the area of study

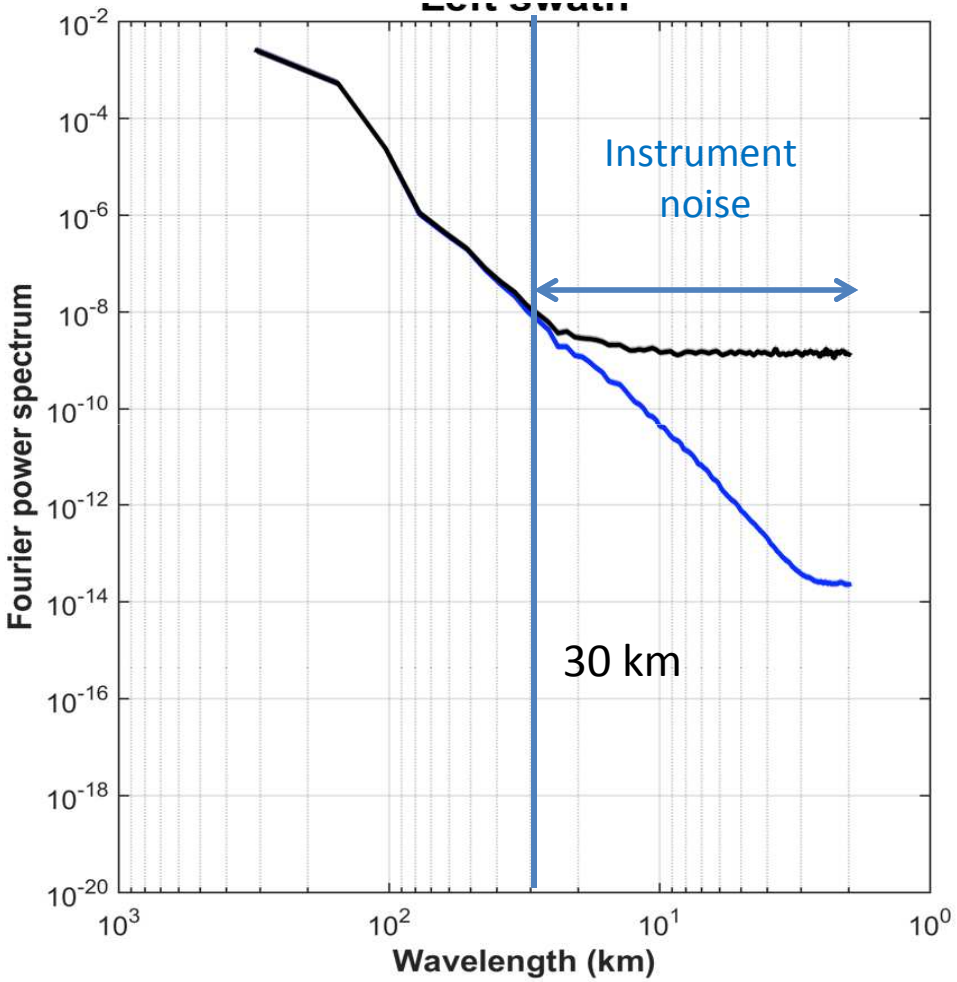
## SWOT simulator

- Application of the SWOT simulator (Gaultier et al. 2016)
- Input data: ROMS simulations
- Western Mediterranean OPerational forecasting system (WMOP) – SOCIB
- 2009 – 2015 hindcast
- Spatial resolution of 2 km (Juza et al. 2016)
- High resolution atmospheric forcing (3 h, 5km)
- Allows to resolve mesoscale and permits submesoscale



Gómez-Navarro et al. (2016)

# SWOT simulator – spectra




Pass 15 – 123 cycles average

SSH model
SSH obs
SSH obs LD filter

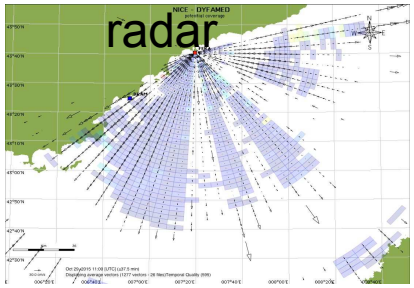
- SWOT simulated data resolve wavelengths > 30 km.
- Significant improvement compared to standard altimeter gridded fields that resolve wavelenghts > 150-200 km.
- Limitations of simulator and model.

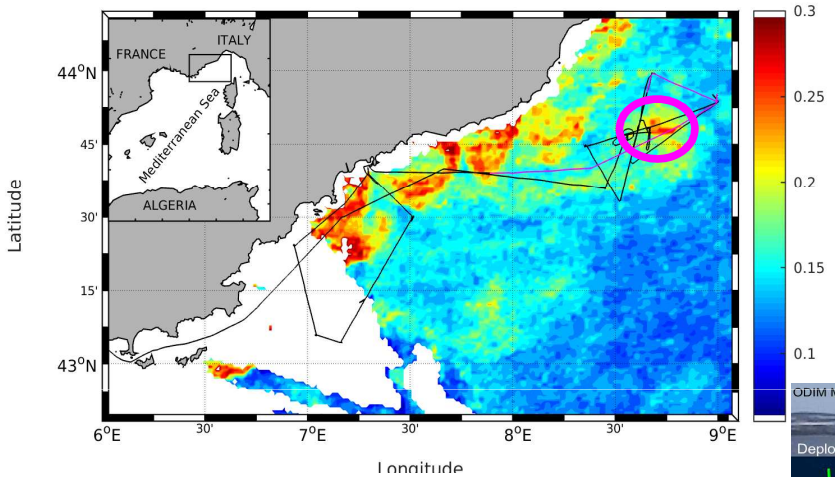
# BIOSWOT (PI: F. D'Ovidio) – some experimental results

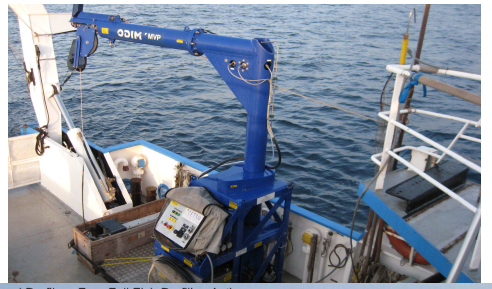
## 2015 OSCAHR campaign (A. Doglioli)

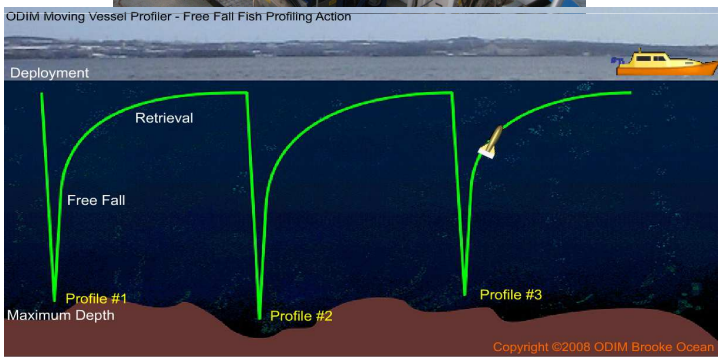
1. Developing fine-scale multiplatform biophysical competences
2. Explore the link between fine-scale physics and phytoplankton diversity

HF radar








Thermosalinograph

Fluorimeter

**Automated flow cytometer Cytosense**

*high-throughput sampling*
*(20' → 3.7 to 2.4 km)*

**MVP (Moving Vessel Profiler)**
Multi-Sensor Free-Fall Fish:
CTD
Fluorescence
Laser Optical Particle Counter
*~2 km horizontal resolution*
*~1 m vertical resolution*

# Summary

- Need of integrated multi-platform and interdisciplinary approach for understanding fine-scale processes
- Smaller, faster ocean dynamics need more rapid in-situ deployments
- Multi-platform approach helps to understand the 2D dynamical evolution
- Integration with remote sensing (SST, OC, along-track and gridded altimetry) and modeling
- SWOT multi-platform experiments prior to launch are required to prepare CAL/VAL and better characterize the area(s) of study
- Joint experiment in 2018 (SW Mediterranean Sea): Spain (PRE-SWOT, MINECO) and France (BIO-SWOT, CNES) + others?. Integrate competences (ship, ADCP, gliders, drifters, underway ctd, underway phytoplankton community, remote sensing, modeling…)

A GODAE International School in Mallorca

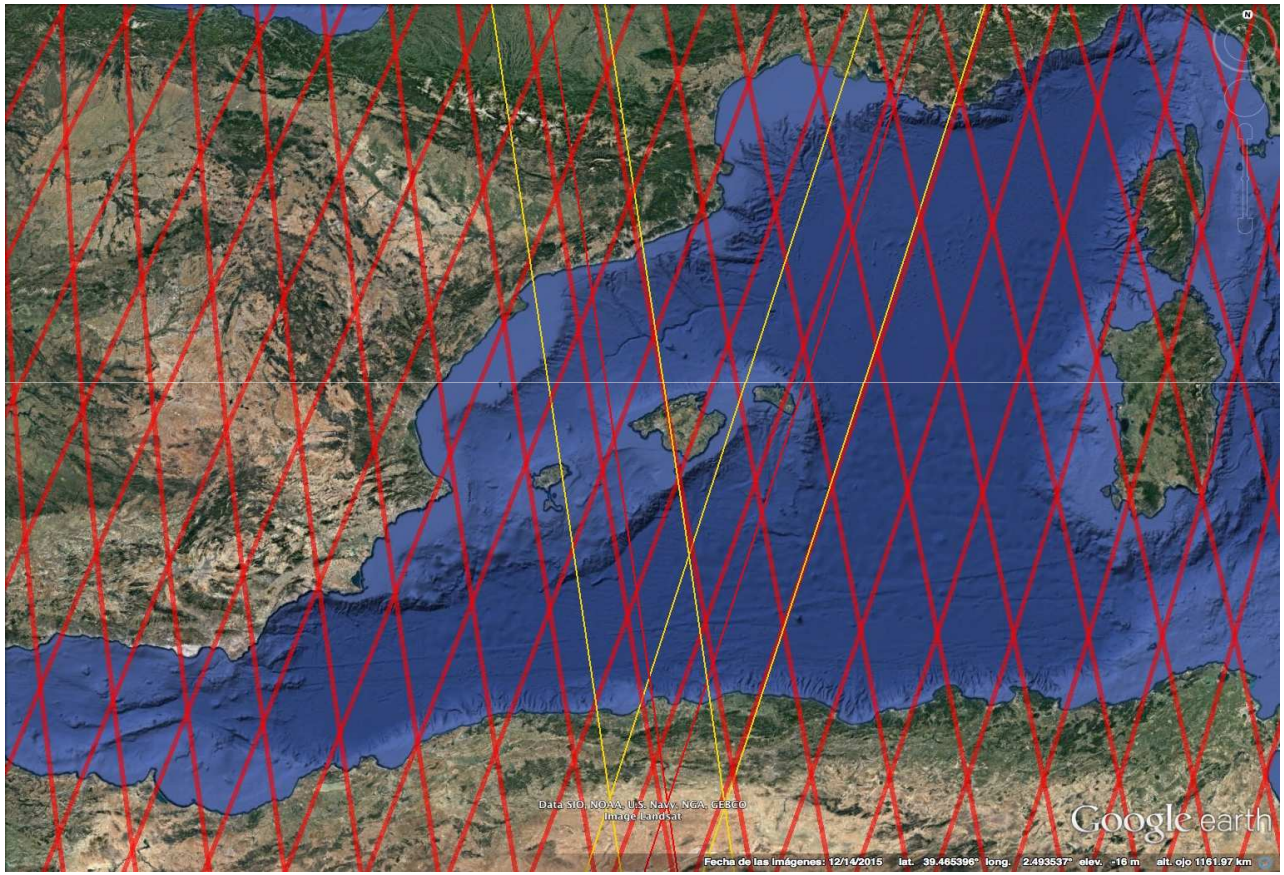
**New Frontiers of Operational Oceanography**


# Thank you!

# Extra slides

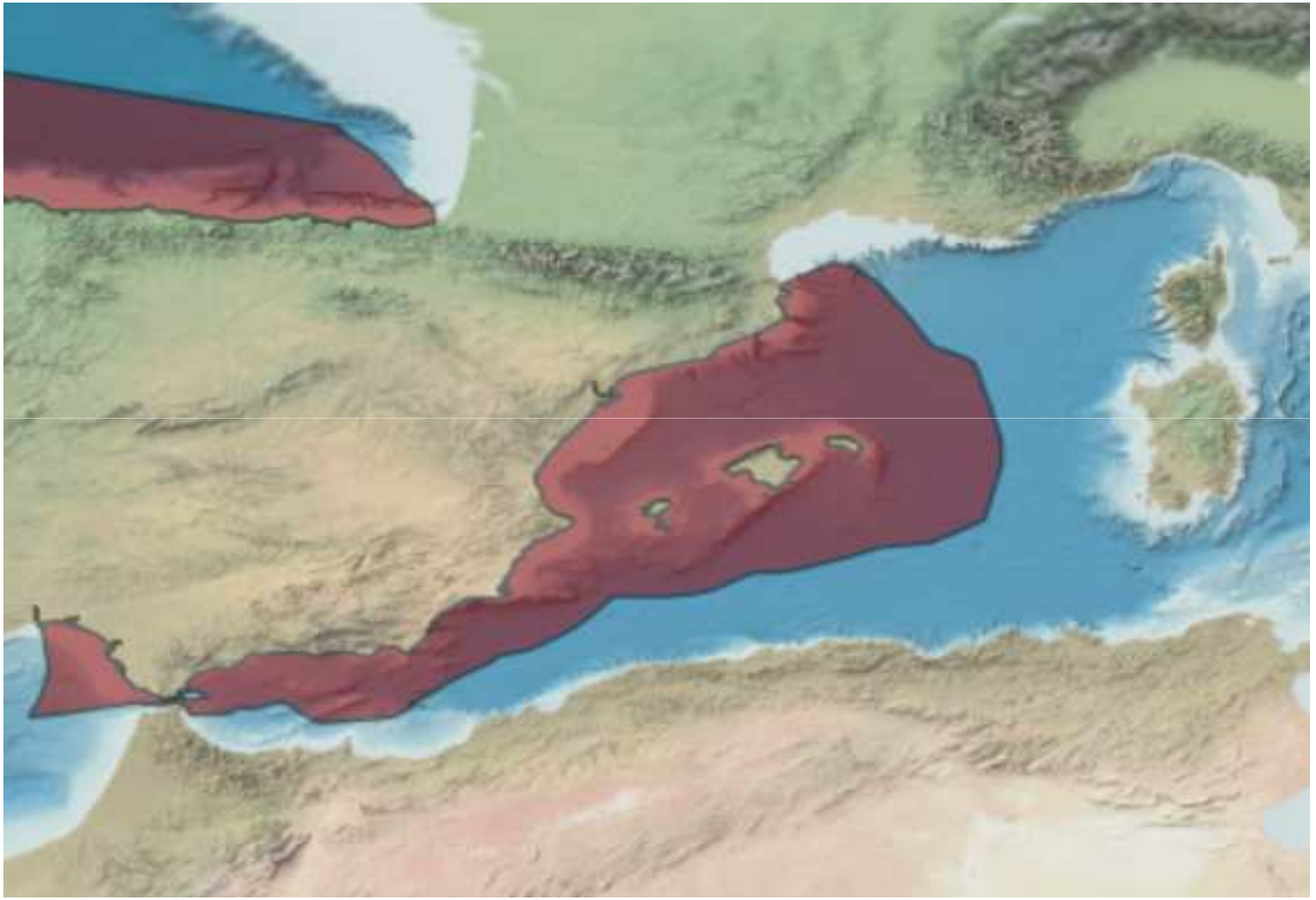
# Anticipating SWOT launch

Multi-platform experiment along a Sentinel-3 track



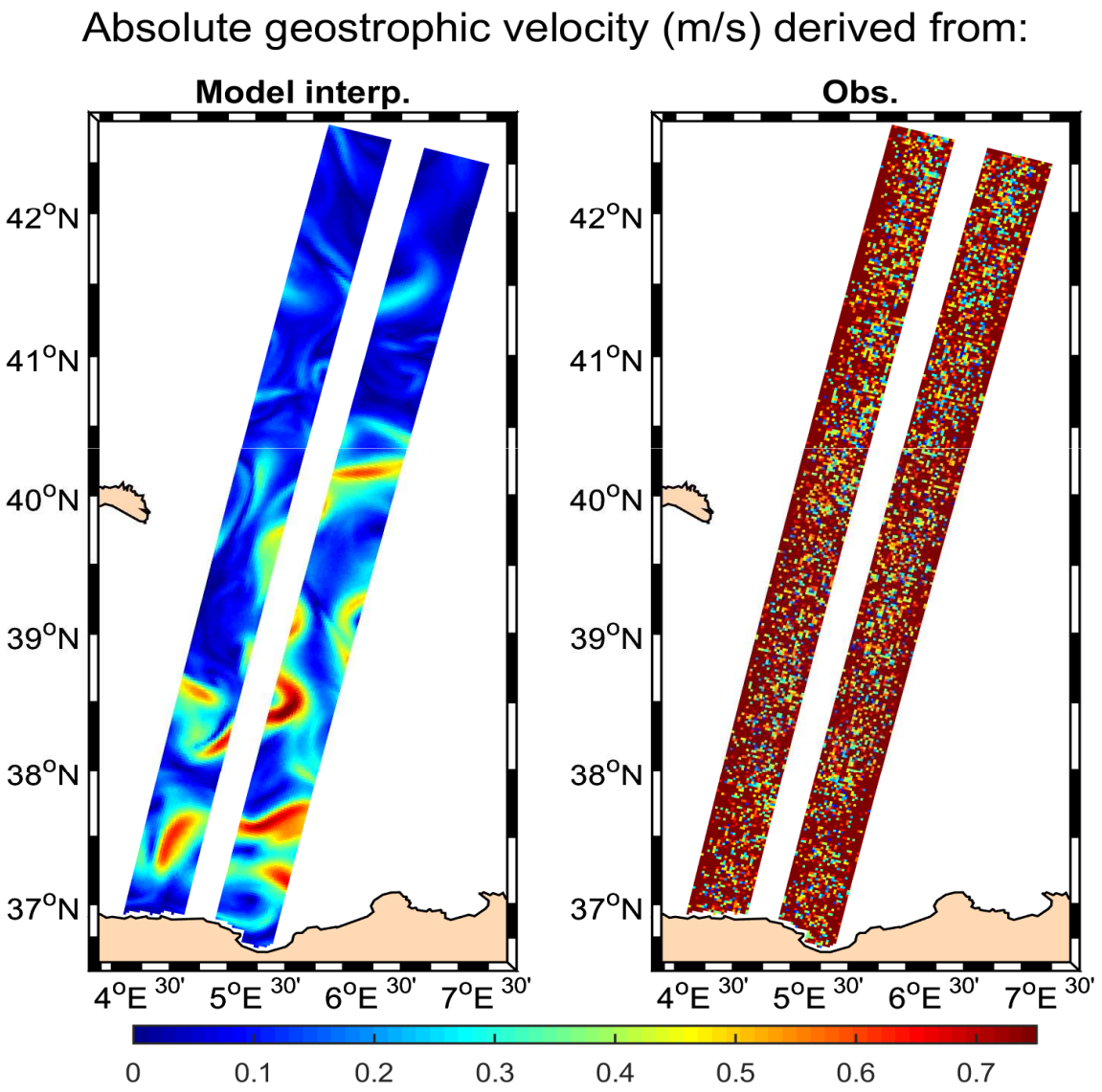

SWOT (fast phase) + S3A tracks

# Spanish EEZ

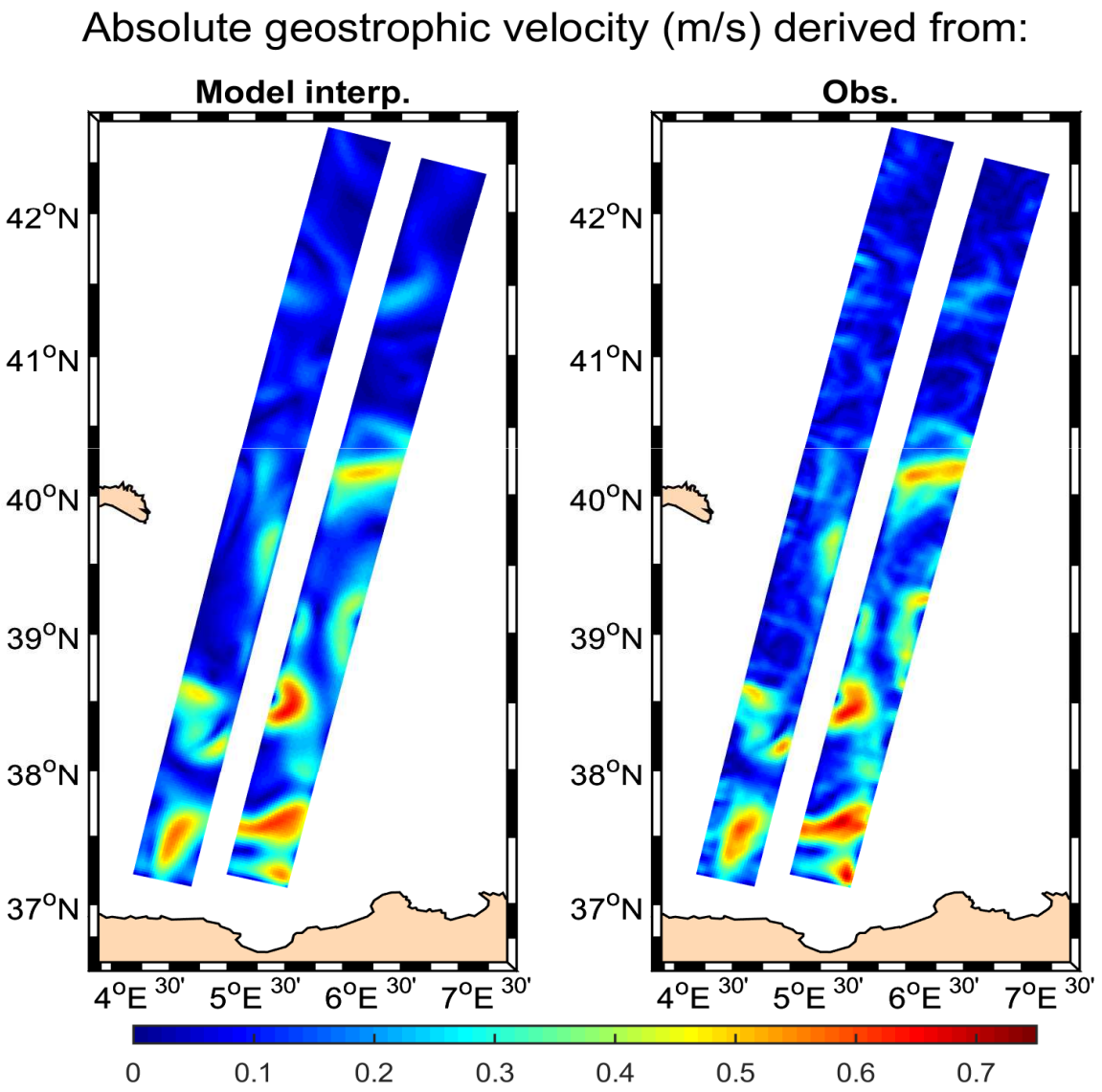


http://www.marineregions.org/gazetteer.php?p=details&id=5693

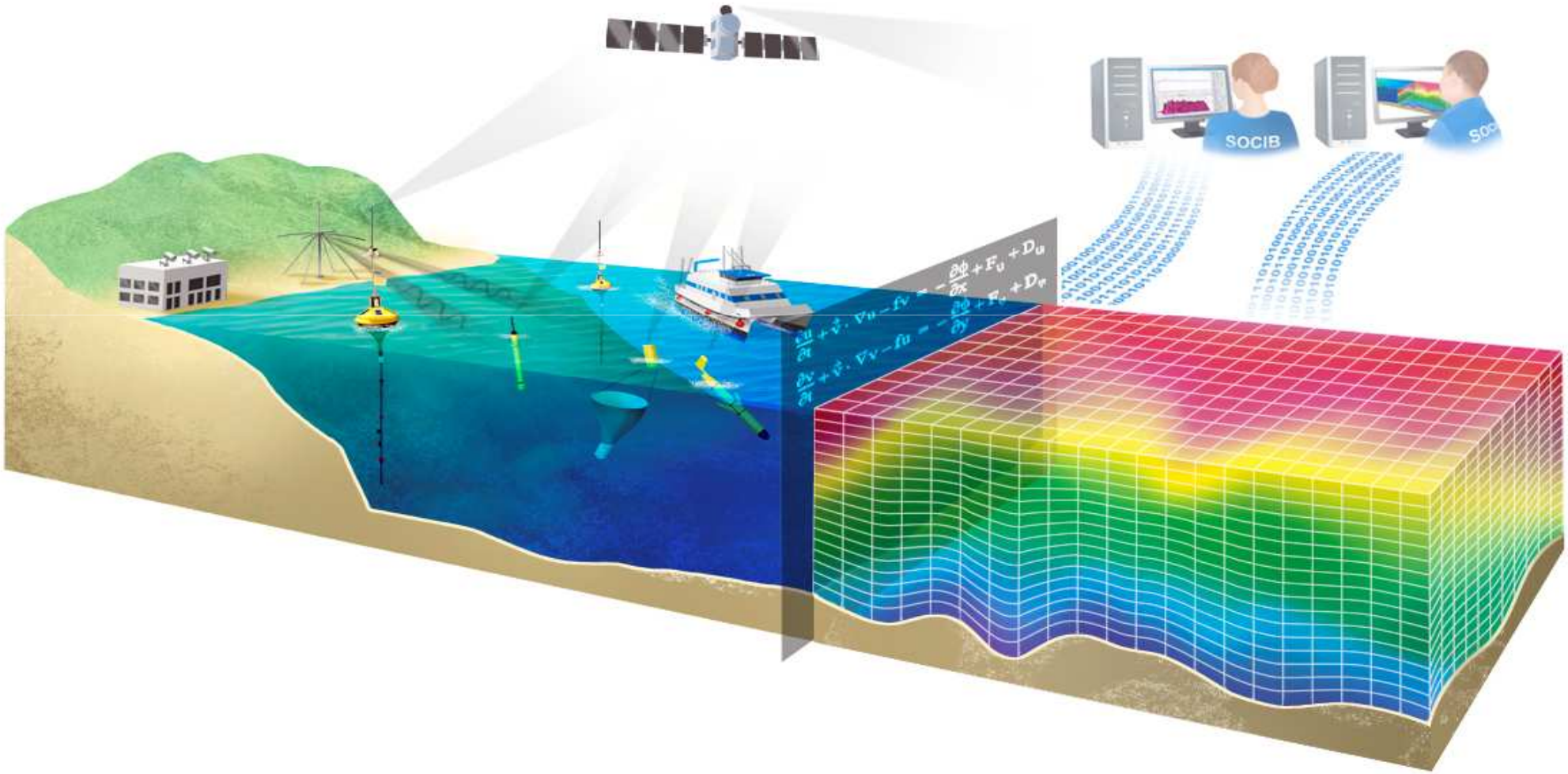
# SWOT simulator – impact of noise (velocity)



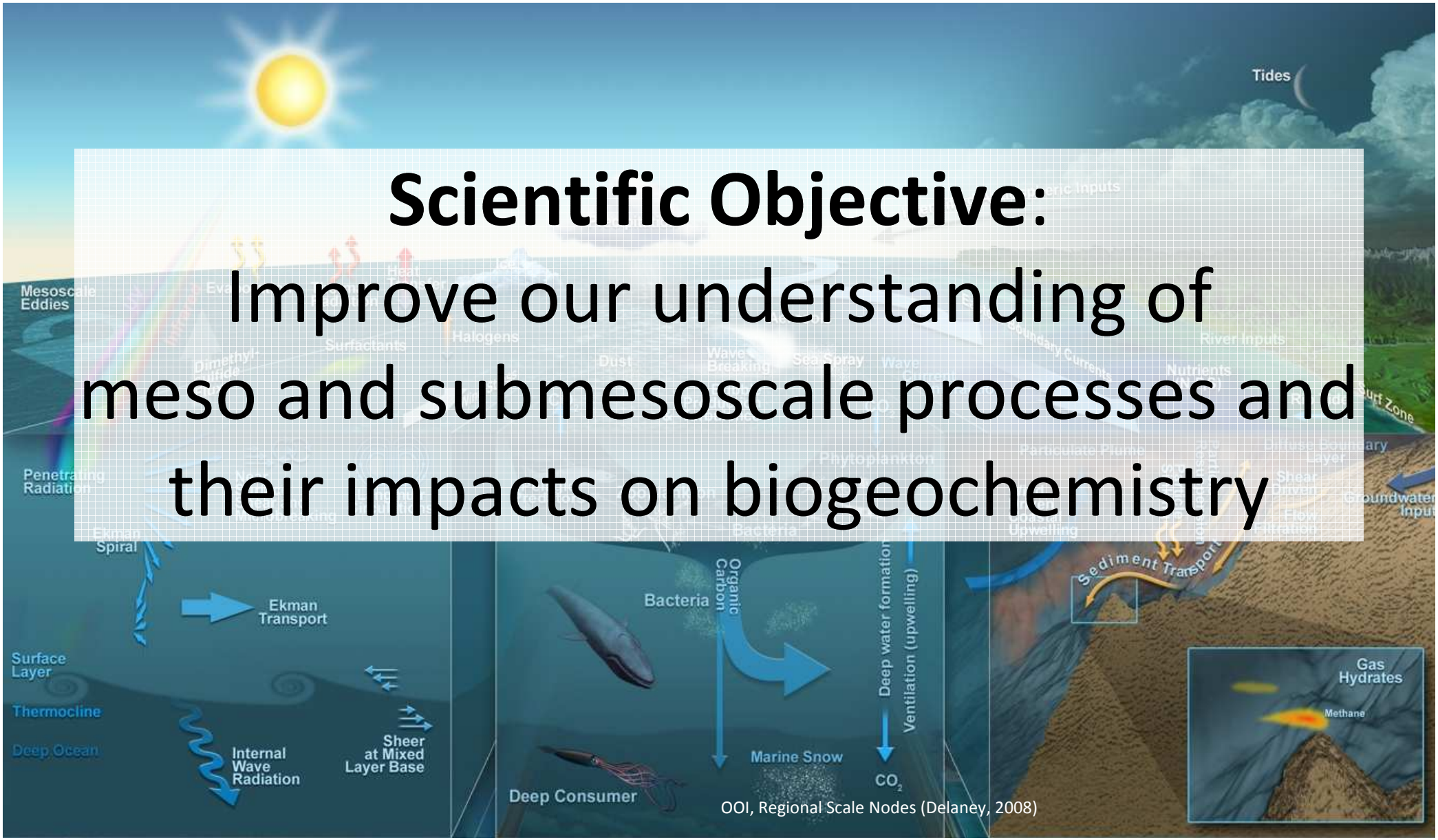
# SWOT simulator – impact of noise (velocity –filt)



# Observations complemented with numerical simulations



**From: single scientist / single process studies… (still needed!)**
**To: joint observing systems of our oceans & interactions**

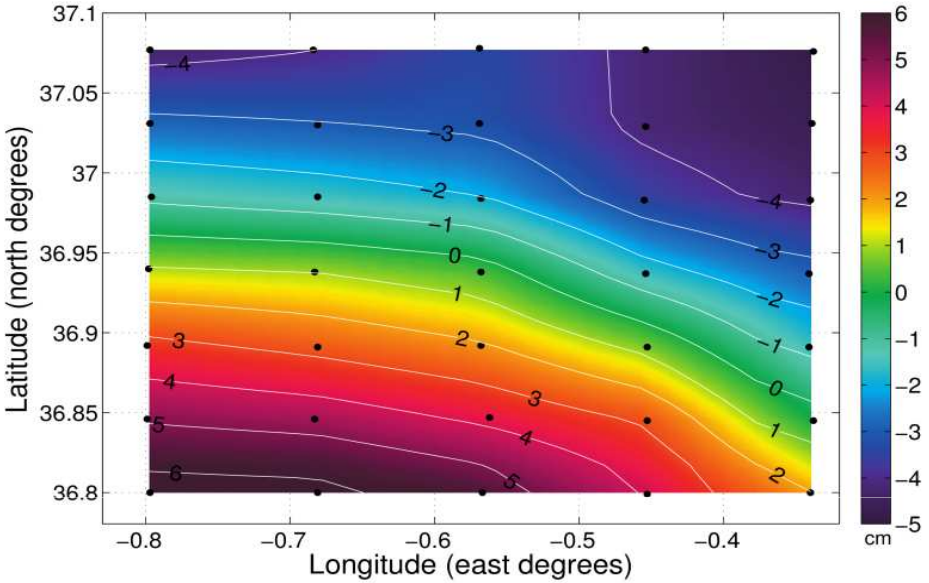



# Scientific Objective:

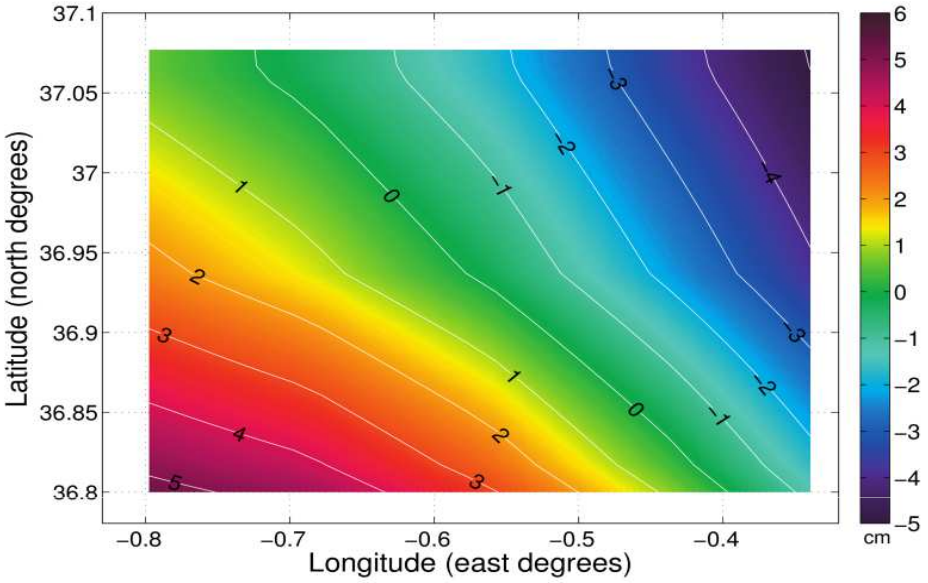
Improve our understanding of meso and submesoscale processes and their impacts on biogeochemistry

OOI, Regional Scale Nodes (Delaney, 2008)

# DH vs ADT (2D)




Dynamic height (DH) at 5 m (ref. lev. 600 m) from CTD survey ALBOREX 26-27 May 2014



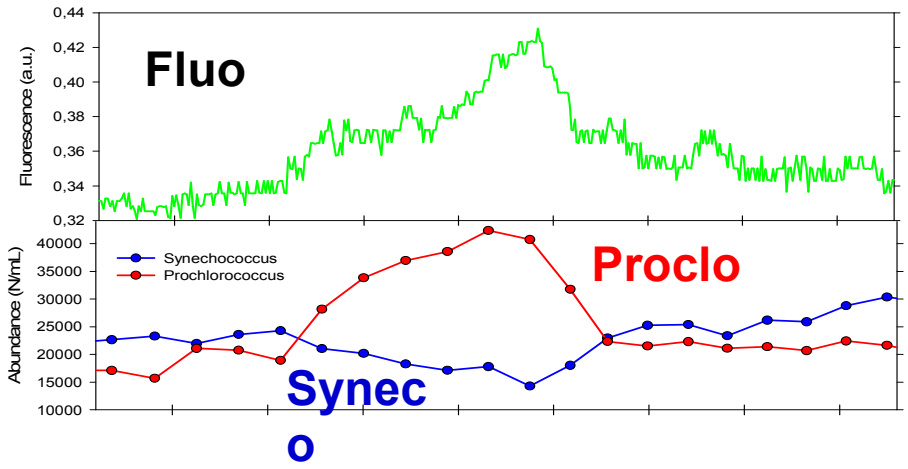

Absolute Dynamic Topography (ADT) from CMEMS/AVISO 26 May 2014 MDT from Rio et al. (2014)

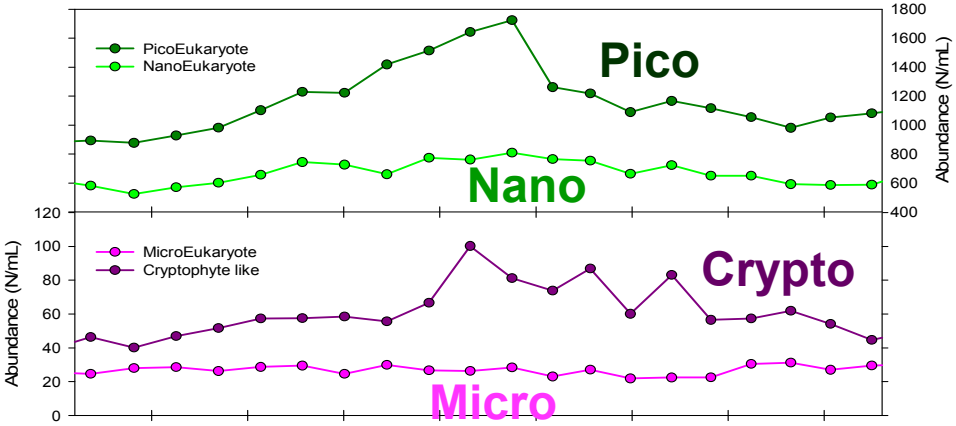
Rmsdiff: 1.82 cm
Corr: 0.82
Var DH: 9.25 cm2
Var ADT: 5.17 cm2

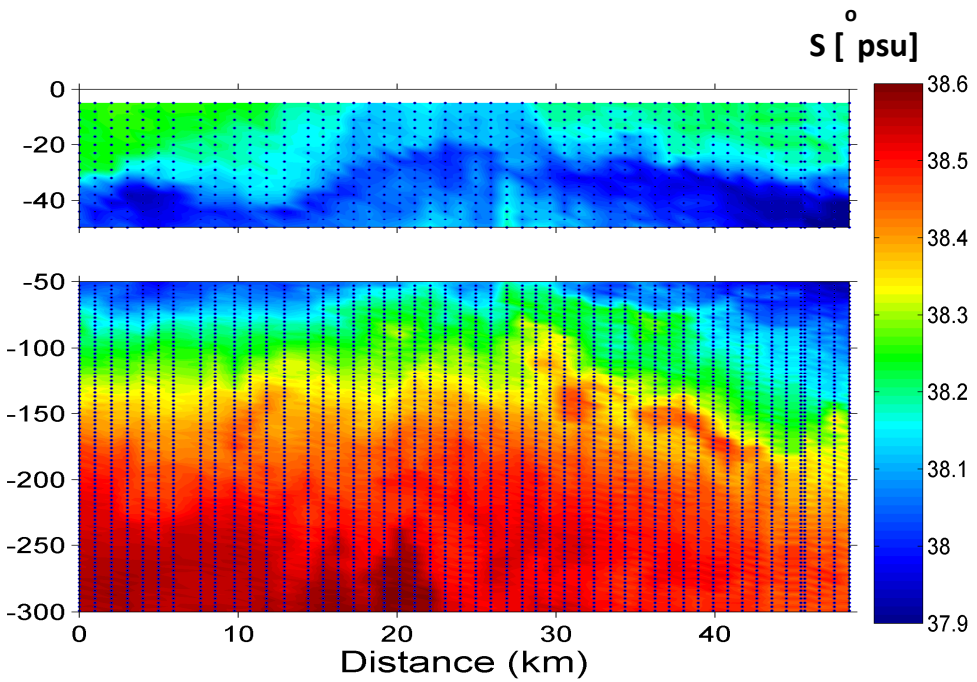
# BIOSWOT – some experimental results

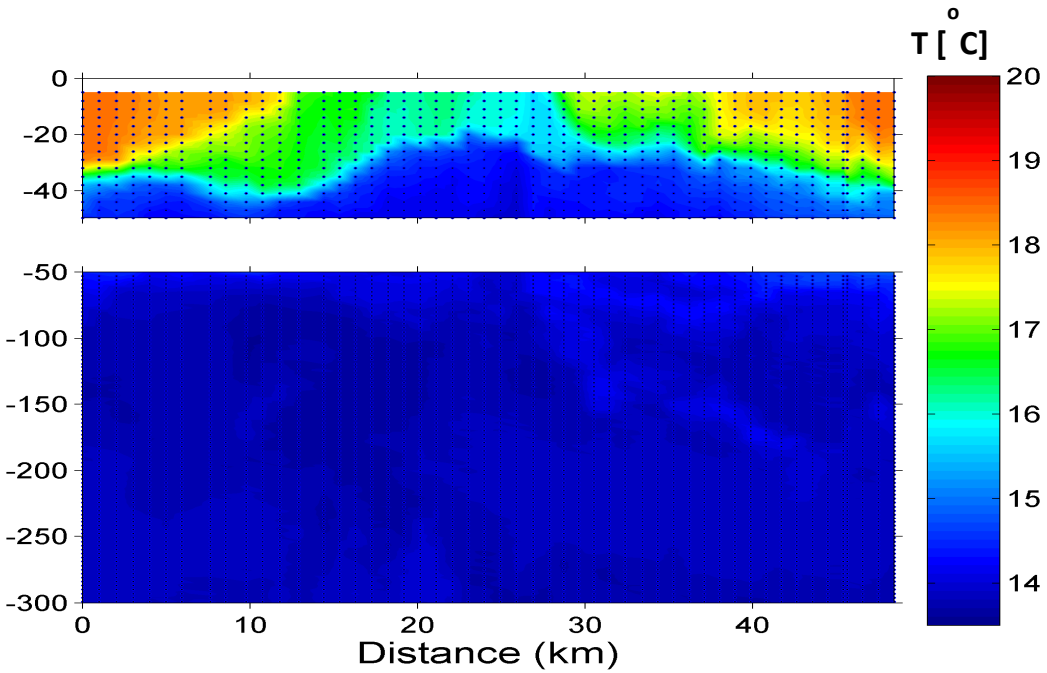
## Underway CTD

## Underway phytoplankton assemblages



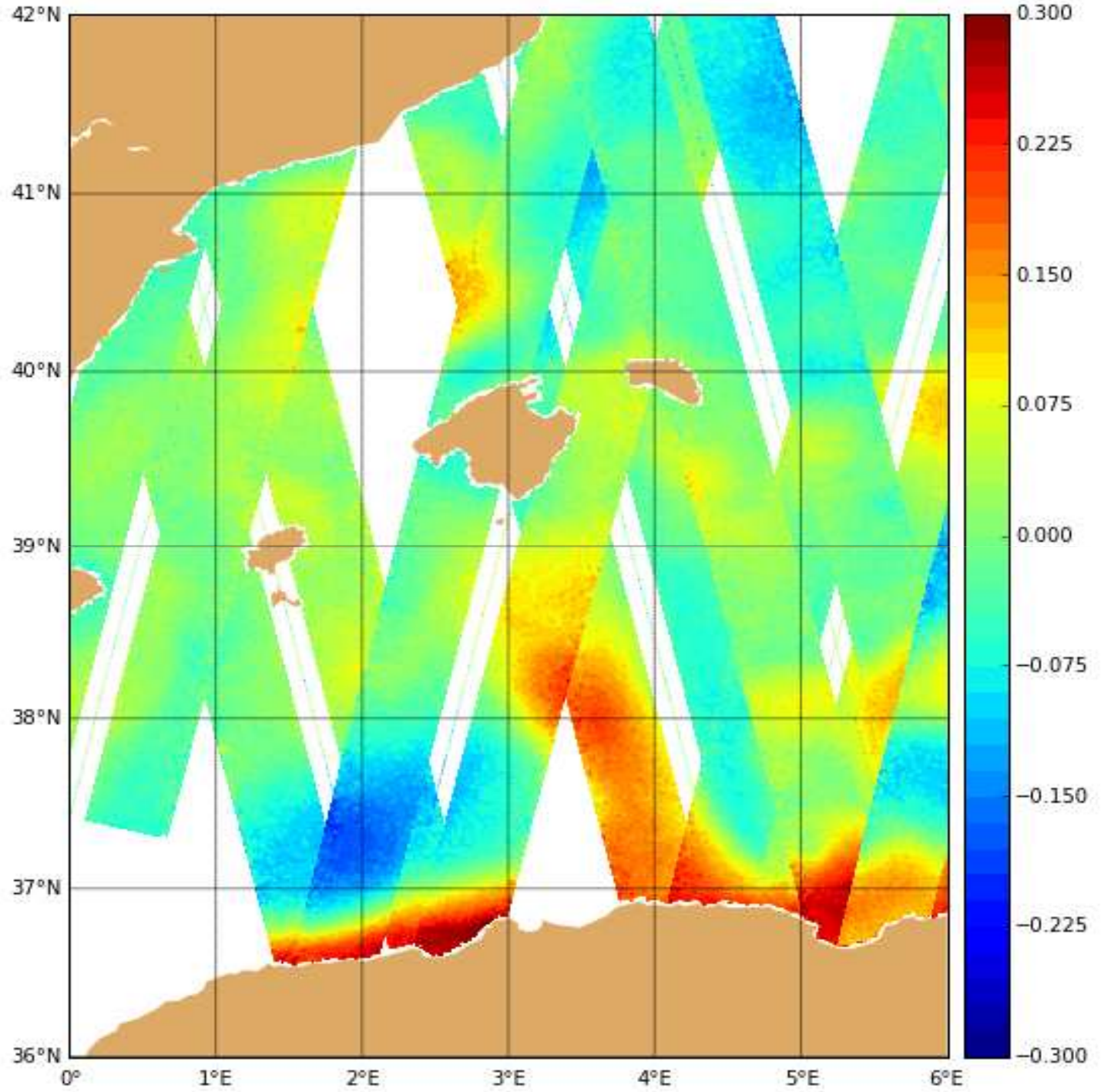



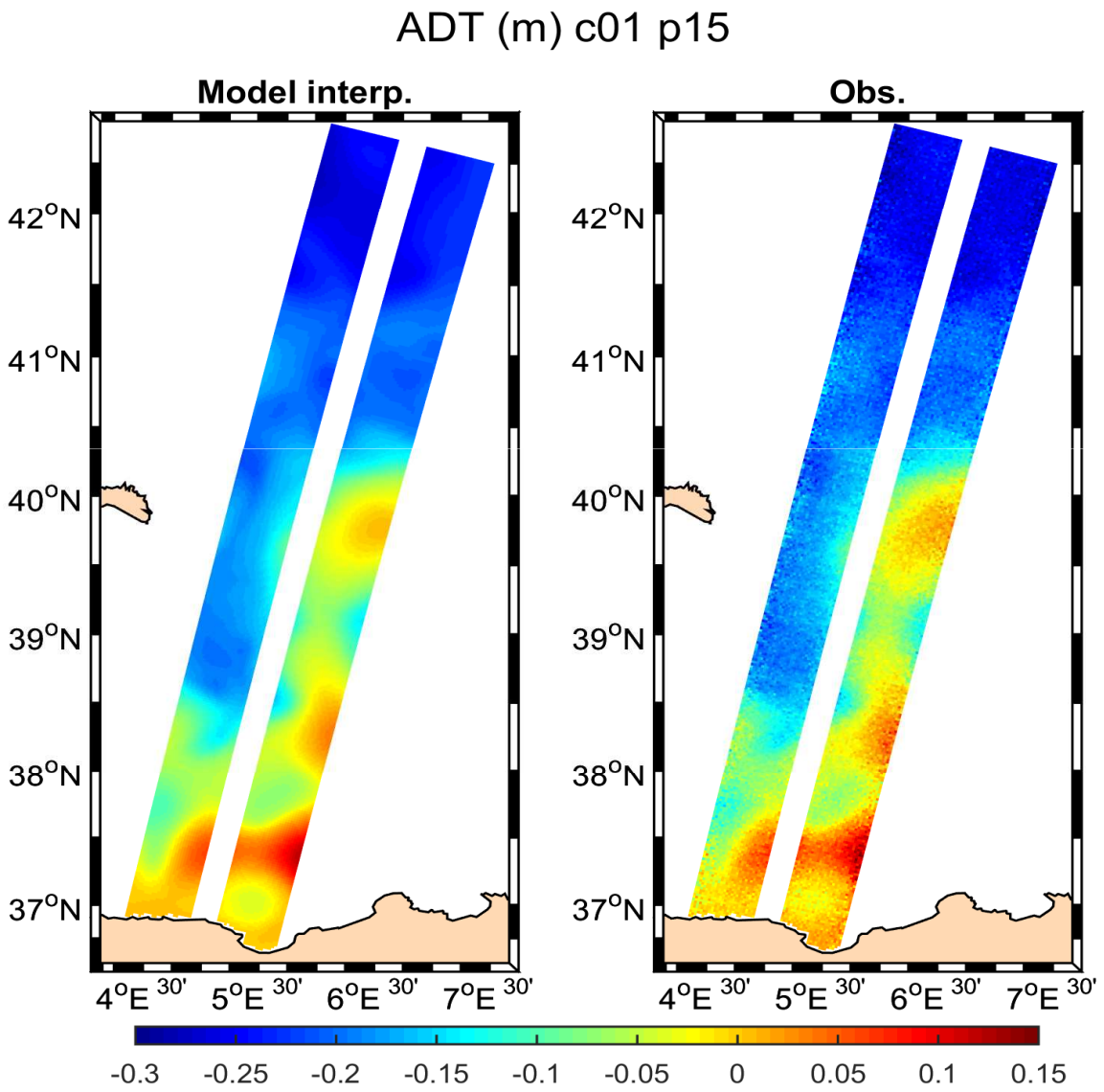
Pseudo-SWOT SSH (m)

**Days: 21-31**

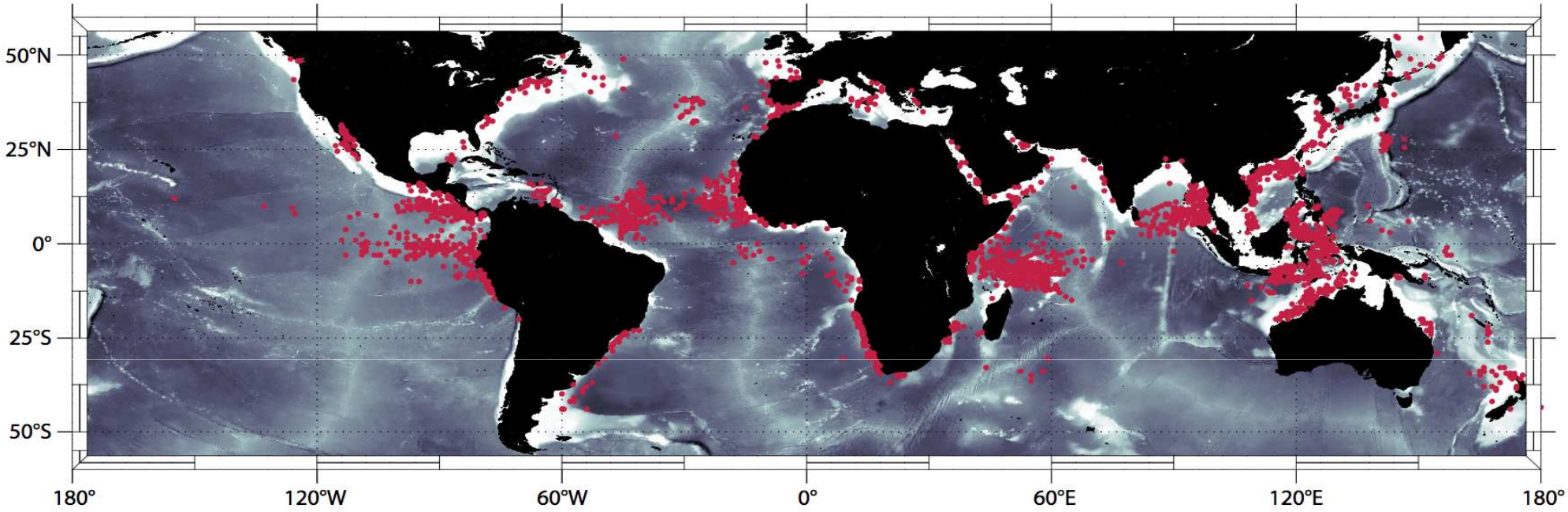
Cycle 2 passes



# SWOT simulator – impact of noise (SSH)



# Low nonlinear internal waves




Location of nonlinear internal observed in 250 m resolution MODIS satellite sunglint imagery acquired from august august 2002 through May 2004 (Jackson et al. 2012)

**From: single scientist / single process studies… (still needed!)**
**To: joint observing systems of our oceans & interactions**

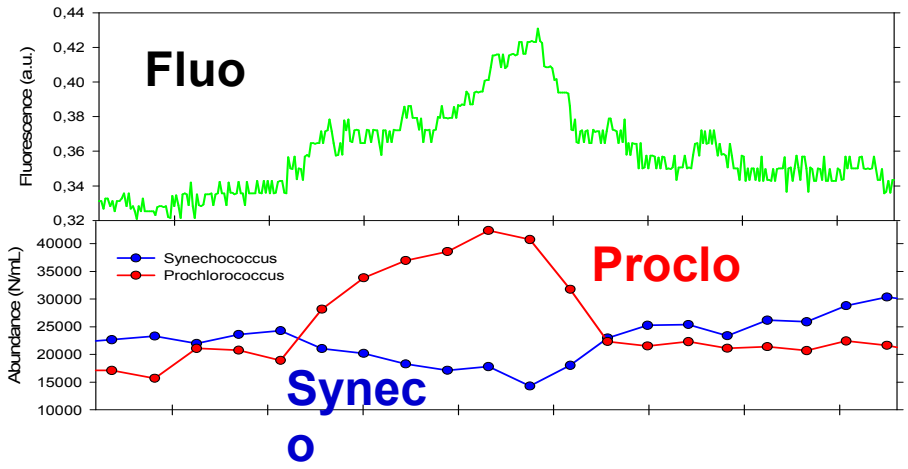

***…. Monitoring … at the right scales…!!***

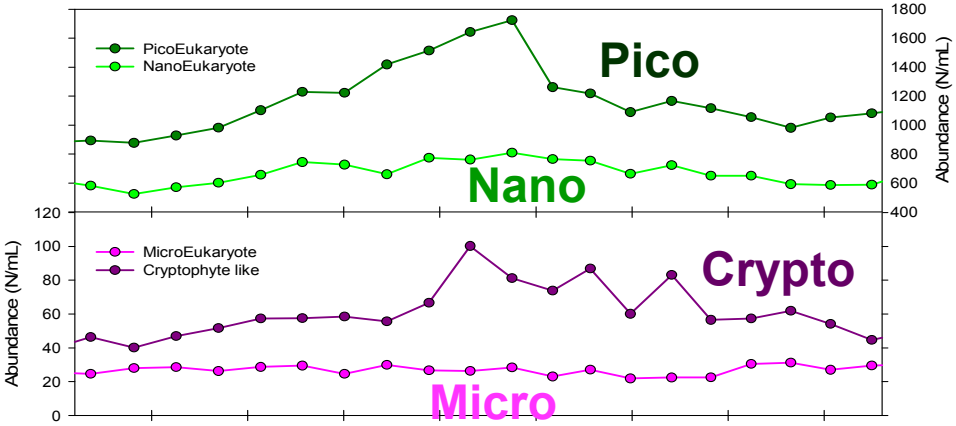
OOI, Regional Scale Nodes (Delaney, 2008)

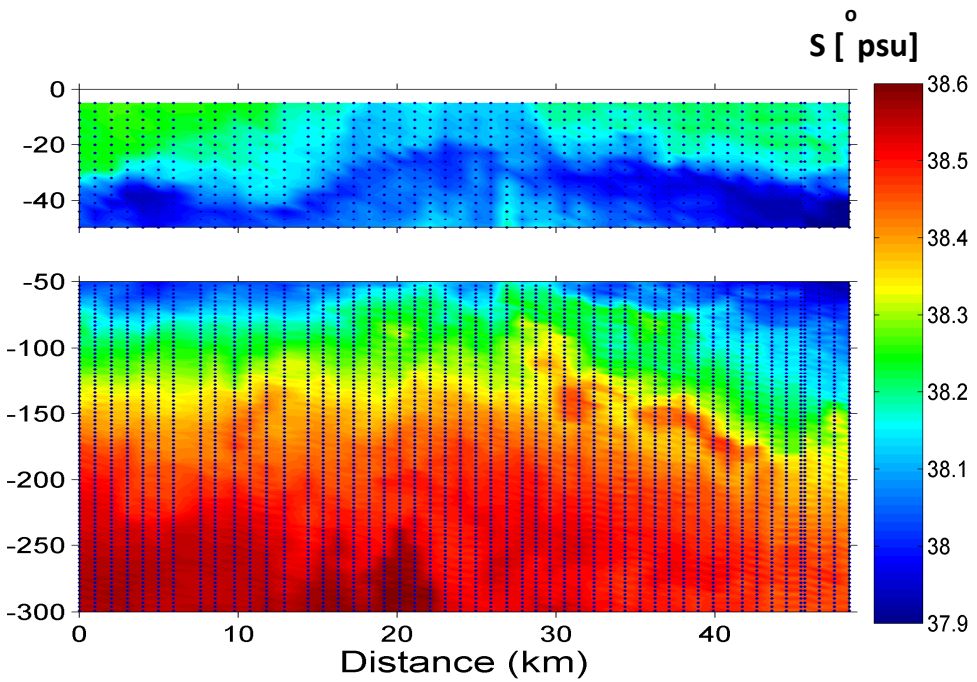
# BIOSWOT – some experimental results

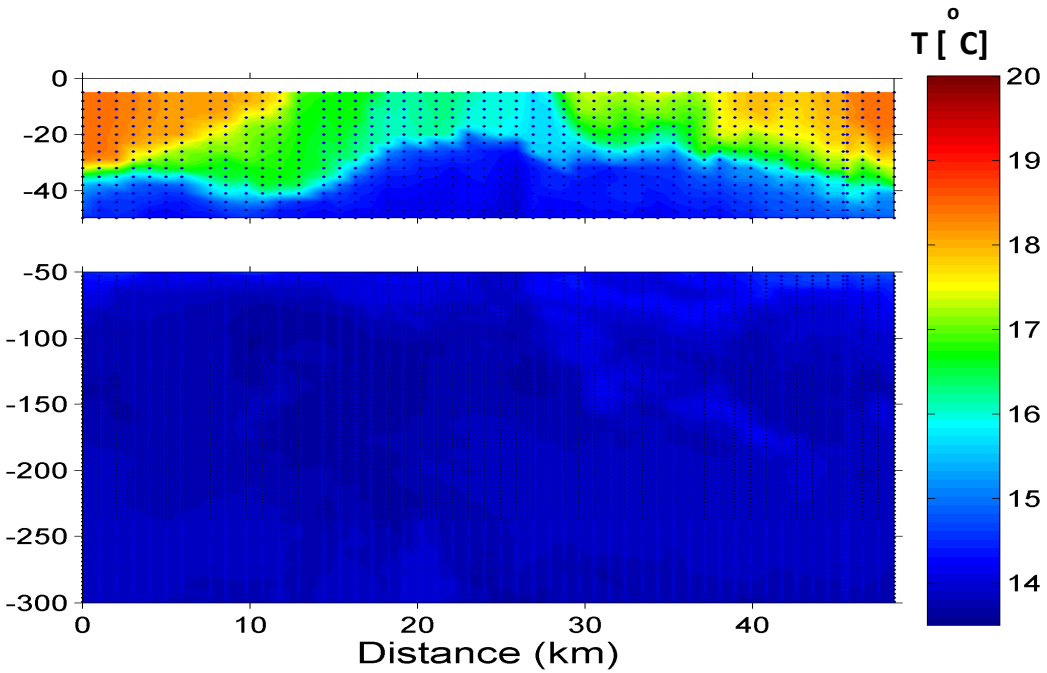
## Underway CTD

## Underway phytoplankton assemblages



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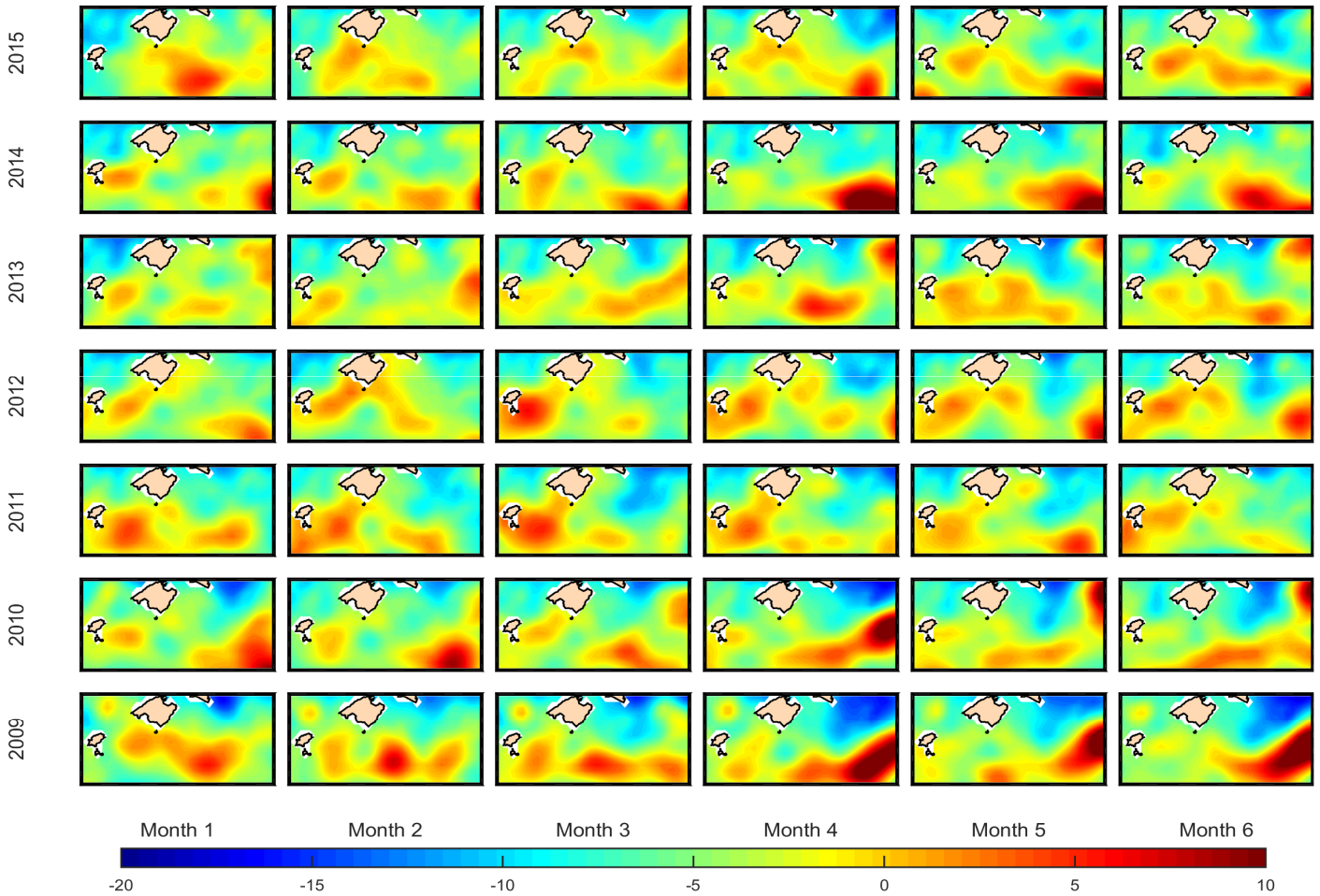


Monthly ADT means (CMEMS altimetric data)

Gómez-Navarro et al. (2016)

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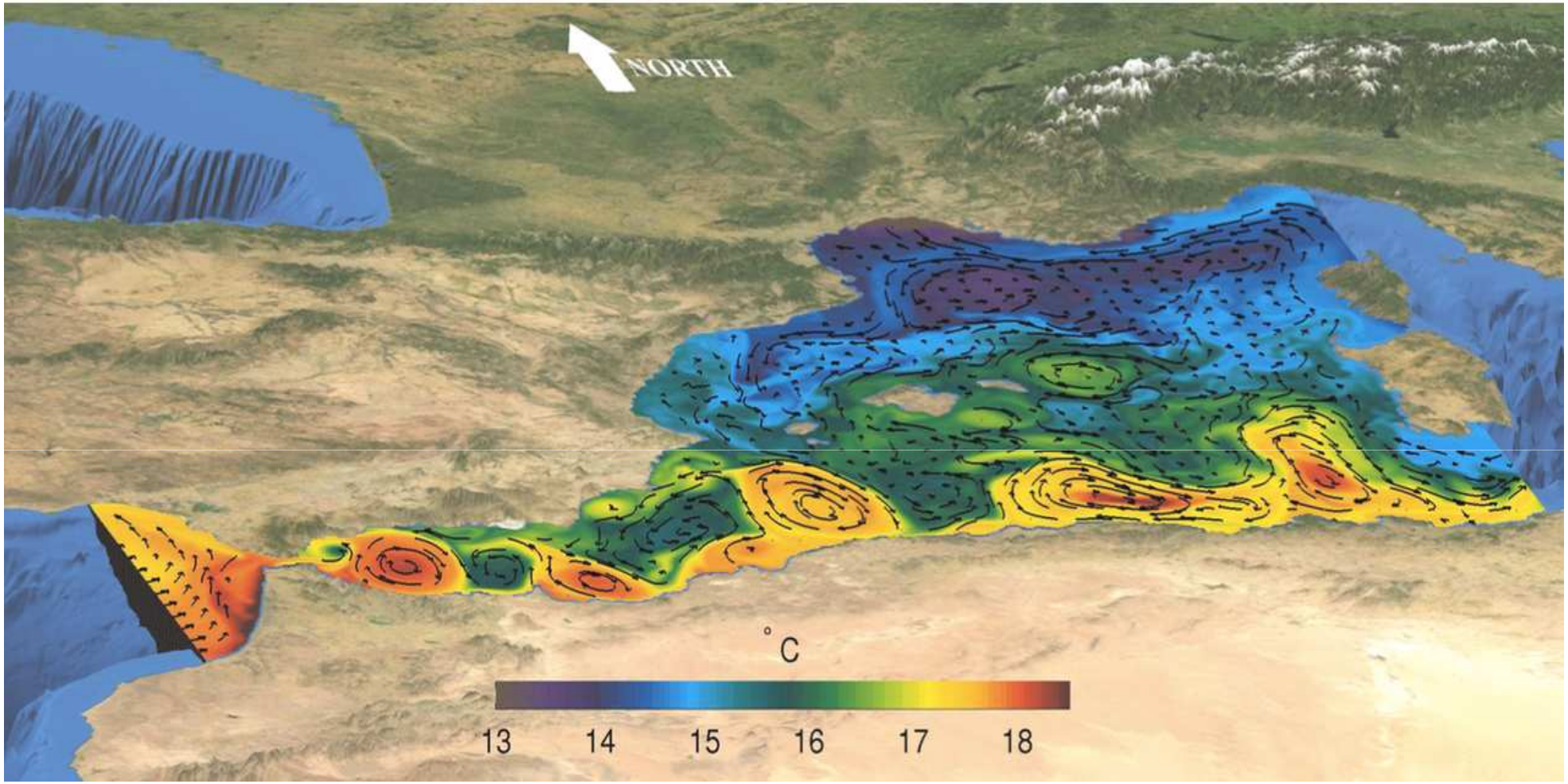


SST and surface velocity from ROMS primitive equations numerical simulations
(Escudier et al., 2016)