PROPOSITION DE STAGE M2 - Année 2023/2024	
Lagrangian study of the fine-scale dynamics during the BioSWOT-Med cruise.	
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Scientific Context

The oceanic fine scales (1-100 km) have relatively short lifetimes (days to weeks) but crucially affect ocean physics and ecology up to the climate scale, due to the strong gradients created by their energetic dynamics. These gradients are associated with strong vertical transport connecting the ocean's upper layer to its interior. Moreover, the temporal scale associated with this horizontal and vertical dynamics overlaps that of many important oceanic processes including biogeochemical cycles, biodiversity, fish distribution, and even foraging strategies of the mega-fauna.

Over the past few decades numerous numerical studies with physical and biophysical configurations for km-scale processes allowed significant progress in characterizing this regime. Field campaigns have also shown that individual fine-scale features may be experimentally targeted, but these in situ studies are usually biased by the choice of targeting the stronger and longer-lived features. Then, an important lack of empirical evidence for moderately energetic fine-scale processes remains.

Programmatic framework

The scientific community has been focusing large efforts on novel platforms. Among these are satellite missions that provide extended coverage and high spatio-temporal resolution of the ocean surface. Obviously, remote sensing does not provide ground truth of all fine-scale physical and biophysical processes, but can provide a critical resource that helps defining the synoptic context of fine-scale features, disentangling spatial from temporal variability, supporting adaptive in-situ sampling strategies, and assessing the representativeness of field data. In this context, the NASA-CNES satellite SWOT (Surface Water and Ocean Topography), launched on 16 December 2022, is the most ground-breaking mission for ocean science in the near future. Indeed, with respect to current nadir measurements the new SWOT altimeter sees two-dimensional scenes (Fig. 1), like sea surface temperature and ocean color, but without being affected by clouds. Moreover, during its initial so-called « fast sampling phase », it associates high spatial resolution with a 1-day revisit period over ~150 km wide oceanic regions, a feat never achieved in the past, and not expected from other planned missions in the future.

The BIOSWOT-AdAC project (PI F.d'Ovidio, A.Doglioli, S.Speich and P.Garreau), funded by the NASA-CNES joint call for the SWOT Science Team, focuses on the specific opportunities of the SWOT fast sampling phase, promoting the international consortium SWOT-AdAC endorsed by CLIVAR, coordinating several field campaigns during this specific period of the satellite mission (www.swot-adac.org, Fig. 2).

The BIOSWOT-Med field campaign contributes to this international effort, focusing on the Western Mediterranean Sea. The latter is the ideal area to verify the hypothesis considering the fine scale circulation as the driver of the plankton biodiversity. Indeed, here a high biodiversity is associated to conditions of oligotrophy and moderate energy representative of a large majority of the world Ocean, unlike oceanic areas as western boundary currents or eastern boundary upwellings that are largely explored and where the intense dynamics or the large nutrient input can mask the fine-scale coupled dynamics. An adaptive and Lagrangian sampling strategy was applied combined with innovative methodologies allowing to obtain high spatio-temporal resolution multidisciplinary measurements in the SWOT swaths (see figure below, with the SWOT ground tracks in gray and the ship's route colored by date).

The BioSWOT-Med cruise (A.Doglioli, G.Grégori, 2023, RV L'Atalante, https://doi.org/10.17600/18002392) aims to improve our understanding of the coupling of physical processes to biological ones from viruses to zooplankton. Our highly interdisciplinary research aims at highlighting the importance of the SWOT mission for biogeochemical and ecological studies. Finally, our in-situ experiment will also bridge a long-standing gap between modelling and global observations assessing the role of the ocean fine scale on the Earth system.

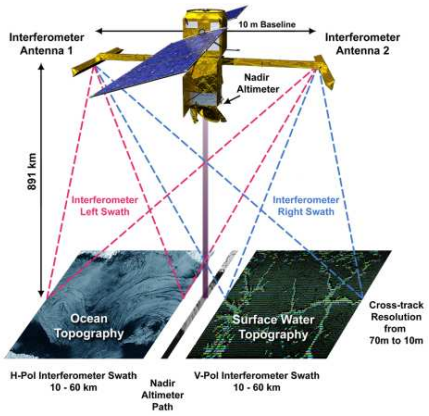

Fig. 1. Scheme of SWOT *(Surface Water and Ocean Topograhy)* satellite functioning. From https://swot.cnes.fr/ .

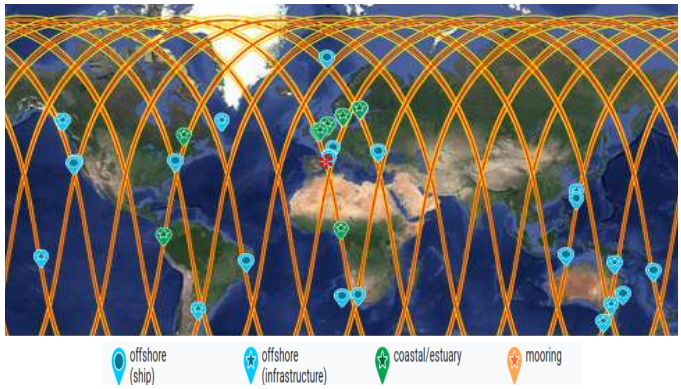

Fig. 2. Track of SWOT during the fast sampling phase and the areas sampled during the fast sampling phase by the participants to the international *"Adopt a cross-over"* consortium (www.swot-adac.org). The red star shows BioSWOT-Med site.

Scholarship goals

The scholarship work will focus on the exploitation of the Lagrangian in situ data collected during the BioSWOT-Med cruise.

In order to validate the new observations of the SWOT satellite and to study the details of the ocean currents, a large number of surface drifters were released in the SWOT swaths during the BioSWOT-Med cruise (Fig.3): 10 SVPs and 10 CODEs (OGS, Italy), 20 CARTHE (ISMAR-CNR), 15 eOdyn (SWOT-AdAC international consortium), two Spotter (LOPS) and 8 additional SVPs from SCRIPPS Inst. (US).
Moreover, a prototype surface drifter equipped with a set of biogeochemical sensors (ISMAR-CNR, Rome) was deployed and recovered before leaving the study area.
Additionally , 6 ARGO profiling floats by OGS (Italy) and LEFE-GMMC (France) were deployed.
These instruments still drift in the study area providing very useful insights of the evolution of post-cruise conditions.

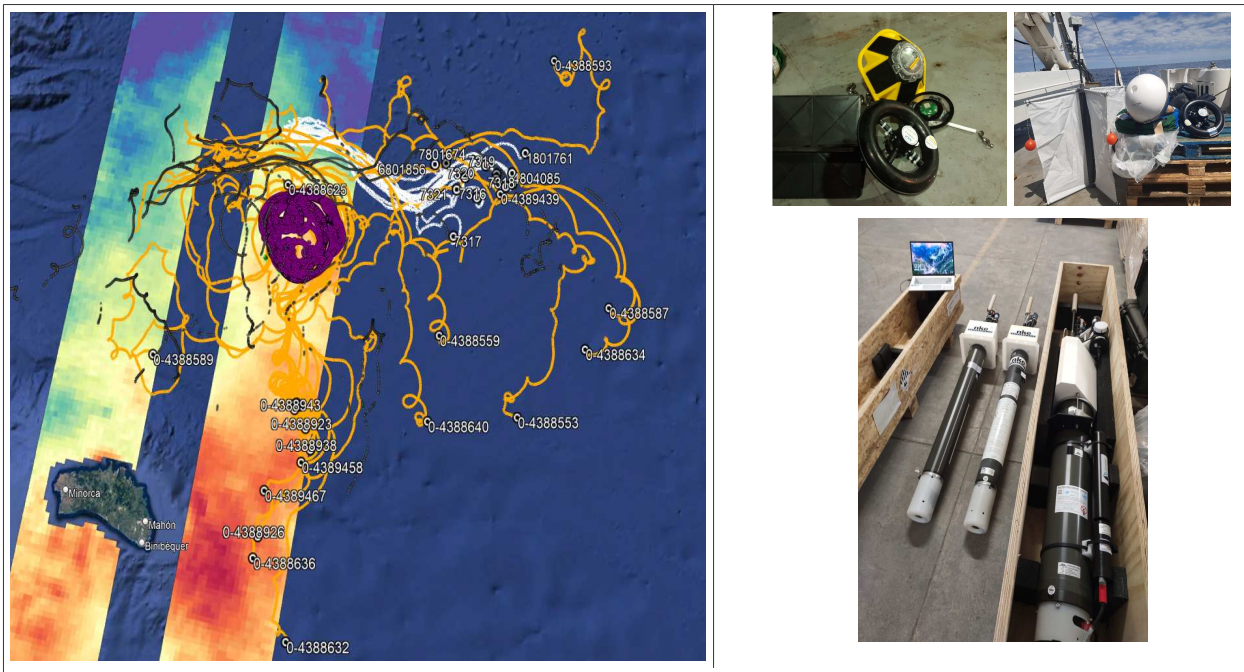

Fig.3. Trajectories and pictures of the different Lagrangian platforms deployed during BioSWOT-Med.

The first goal of the scholarship will be the treatment analysis of the datasets obtained with the different Lagrangian platforms in order to reconstruct the ocean dynamics during and after the cruise. In particular, the student will focus on surface drifters, studying the possible differences in drifters' trajectories associated to their physical constrains (e.g., depth of the drifter drogue or surface expression) and computing relative dispersion properties that may be associated to horizontal and vertical ocean processes, like strain, vorticity and divergence. Estimates of vertical velocities will be calculated based on targeted drifter deployments at different depths (1-15m). This part of the study will benefit of code and skills of the hosting group and will allow to intercalibrate different models of drifters and to prepare to the second goal.

The second goal is to perform Lagrangian simulations with LAMTA (Lagrangian Manifolds Tracking Algorithm, also included in the SPASSO software package) exploiting both the standard AVISO altimetry-derived currents and the new high resolution data by SWOT to cross-compare satellite and in situ observations. The LAMTA package is a Python code that creates trajectories of virtual drifters starting from a given surface velocity field. The code is already prepared to treat available SWOT Level 3 products (Sea Surface Height) as well as standard products of conventional altimetry. The student will use this code for the period and region of the BioSWOT-Med cruise, and then compare statistical properties of virtual and real surface drifters. Lagrangian diagnostics, already implemented in the LAMTA package, like the retention parameter or the Lyapunov exponent, will allow to identify the presence of fine-scale features like fronts or eddy cores. The student will therefore assess the capacity of SWOT in reproducing fine-scale drifter properties, with a special attention on the spatio-temporal scales that are not visible on conventional altimetry products.

Both tasks will provide a global view of the fine-scale circulation in place during the BioSWOT-Med cruise and affecting the ecosystem in the studied region.

Interests and skills

- knowledge in physical oceanography ; in situ data validation and processing; Lagrangian experiments ;
- computing skills (Python, Matlab, Fortran, Shell) ;
- team work.

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www.swot-adac.org

https://spasso.mio.osupytheas.fr