General presentation

The ocean dynamics at the submesoscale is characterized by structures of a size of a few km and lifetimes of a few days / weeks. They are typically ageostrophic and their dynamics become three-dimensional. Their size represents a barrier to their observation, which has long delayed the assessment of their abundance [McWilliams 2016]: too small and rapidly evolving for conventional measurements of at-sea campaigns and for the first remote sensing satellites, often difficult to distinguish from inertial waves in time series at a fixed point or in vertical profiles. In addition, the difficulties related to their non-linear nature have strongly limited the theoretical predictions. It was only in the 2000s that the resolution of numerical circulation models became sufficient to represent such scales. The models, added to the very high resolution satellite imagery, were the starting point for the study of these structures, which has grown rapidly over the past fifteen years. Indeed, they may represent the "missing step" in the direct cascade of energy from mesoscale to dissipation [Ferrari and Wunsch 2009] and thus strongly impact the vertical transfer of heat and salt.

Submesoscale dynamics also play a key role in the biological processes of the ocean. It can control the injection of nutrients into the photic zone [Mahadevan 2016] and consequently influence the distribution of plankton. In addition, it can generate physical barriers that are thought to play an important role in the development and distribution of ecological niches in the ocean environment and in the connectivity of coastal ecosystems [d'Ovidio et al. 2010]. The vertical mixing associated with these structures can also impact, through micro-scale turbulence, the distribution of plankton. A better understanding and predictability of these structures remains a critical point of a better characterization of the coupling between marine physics and biology.

Programmatic Framework

The SWOT (Surface Water and Ocean Topography, https://swot.cnes.fr/) mission will put into orbit in 2021 the KaRIn instrument, a Ka-Band radar operating on the basis of a SAR (Synthetic Aperture Radar). Current altimetry radars are limited to a band of less than a few kilometers vertically from the satellite. On the other hand, KaRIn will be able to take measurements along a wide swath of about 120 km, thanks to 2 radar antennas located at the ends of a mast of 10 m (Fig.1). This mission will provide hydrologists with the levels of all water bodies on the planet that are larger than 100 m.
In oceanography, SWOT will provide altimetry fields over a width of about 150 km with a spatial resolution that will approach the one of the satellite measurements of SST or water color. Unlike these last two measurements, those of SWOT will not be affected by the presence of clouds. It will therefore be possible to observe by satellite the fine-scale circulation and the coastal circulation, and this, in particular, in the crossing points of the tracks during the first phase of putting the satellite in orbit in 2022 (Fig.2).

As part of the BIOSWOT project funded by CNES, we propose to address the following scientific questions:
- How do submesoscale filament dynamics and associated vertical velocities influence the plankton patchiness?
- Do the filaments act as barriers to transport and mixing, thus contributing to the structuring (diversity and abundance) of plankton?

To answer these questions it is essential to develop observation methodologies with high spatial and temporal resolution of both physical and biogeochemical properties.

In May 2018, we organized the ProteusBIOSWOT campaign carrying out physical and biogeochemical measurements in the oceanic area of the future SWOT crossing point between the Balearic Islands and the Algerian coast (point circled in red in Fig.2 and Fig.3).

The work of this internship concerns the study and analysis of the in situ data collected during this cruise. In particular, the analysis of physical oceanography data and their relationship with biogeochemical observations.

**Goals and perspectives of the studentship**

The first goal will be to characterize the hydrological observations of the campaign based mainly on the analysis and interpretation of the datasets of the surface layer sampling (hull-mounted ADCP, thermosalinometer, SeaSoar profiles, drifting buoys).

The second objective will be to put the observations in the context of the oceanic region with an accurate analysis of satellite measurements (altimetry, SST, CHL).

The third objective will focus on the study of the influence of dynamics on biodiversity (Cytometry).

Being this work a basis for further studies and for the preparation of future campaigns, a PhD studentship is foreseen.
Fig. 3 Map of the sampling route of the R/V Beautemps-Beaupré during the ProteusBIOSWOT-2018 cruise.

Interests and skills
- good knowledge of physical oceanography;
- programming (Matlab, Fortran, Shell);
- team work.

Useful links
http://www.mio.univ-amu.fr/~doglioli/
http://www.mio.univ-amu.fr/~doglioli/BIOSWOT/

Bibliography