Offre de stage :

The power of deep learning applied to oceanic eddy detection

Niveau : M2

Cadre :

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Contexte scientifique objectifs :

The increases of the spatial resolution of numerical models and remote sensing observations both revealed the prevalence of eddies throughout the oceans. These structures are able to trap and transport heat, mass, momentum, and biogeochemical properties from their regions of formation to remote areas. Eddies have therefore a significant impact on the surface circulation at both local and regional scales. In order to investigate a large number of coherent structures for long periods (several years) the development of **automatic eddy detection and tracking algorithms** is now an "hot spot" of research in oceanography. Many objective criterions could be used to detect and identify eddies (Mkhinini et al. 2014, LeVu et al. 2018). However, the remote sensing observations (sea surface height, temperature or color...) are often corrupted by clouds (visible imagery) or by the coarse distribution of altimetric tracks. The combination of distinct remote sensing data-set (SSH, SST, CHL...) could restore the lack of information that may occurs on a single data set. The figure 1 below show how a large meso scale eddy could be misrepresented by the altimetry, when it passes into the gaps between satellite groundtracks, while it is clearly visible by "human eyes" on the SST signal. Our recent work (Moschos et al. 2019) use the eddy detection algorithm AMEDA to locate eddies on altimetry fields and extract on high resolution (1km) SST images (NPP VIIRS, CNR MED L3) snapshots of eddy signatures. Both a reliability index and visual inspection were used to select and validate a first set of 1200 images. Then using pre-trained neuronal network (ResNet18) and image augmentation technics we build a very efficient image classifier EDDIES-HL (96% accuracy!). The main goal of this internship will be to **extend this work on different sets of images such as Ocean Color/Chlorophyll (CHL), or synthetic-aperture radar (SAR images)**. These two types of images also contain clear eddy signatures (see figure 2). However, as for the SST signal, these new set of images contains "noisy labels" due to the intrinsic errors of the altimetry. The main complexity of the task is to treat and correct noisy labels through an extra (but small) subset of accurately labeled images. The goal is to achieve the best performance with a small number of accurately labeled images (selected by visualinspection). The student will pursue the work initiated at LMD by a PhD student in collaboration with the LIP6 (Laboratoire d'Informatique

de Paris 6) in order to design and implement the deep learning methodology on high speed computers. The internship will therefore, be located half of the time at the LIP6, Paris Sorbonne University and the other half at the LMD.

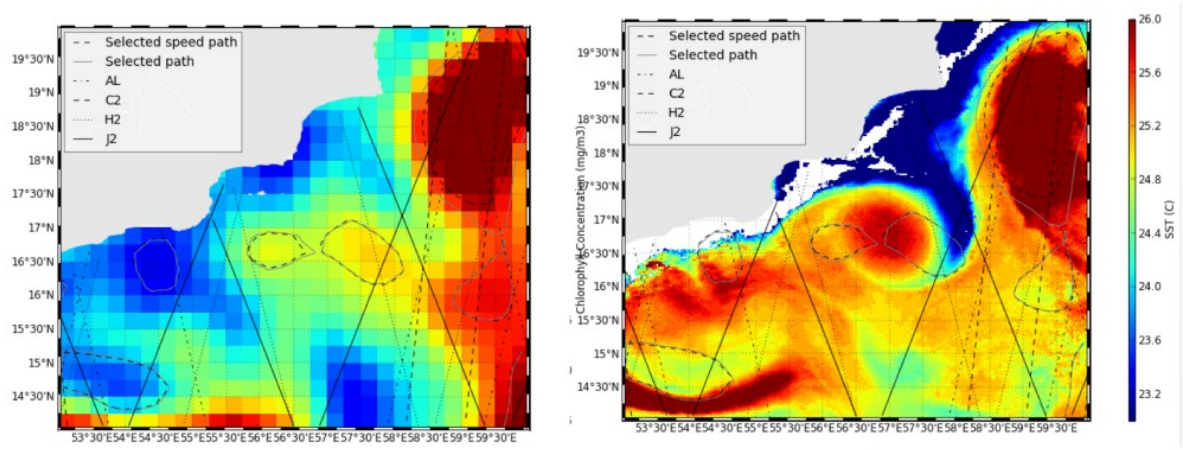

Figure 1 *Sea surface height (left) and Sea surface temperature (right). The solid and dashed lines represent the altimetry tracks while the black contours corresponds to the eddy contours identified by an objective analysis of the SSH field. The warm anticyclonic eddy visible on the SST(right) cannot be detected on the reconstructed SSH (left) due to the lack of altimetry tracks.*

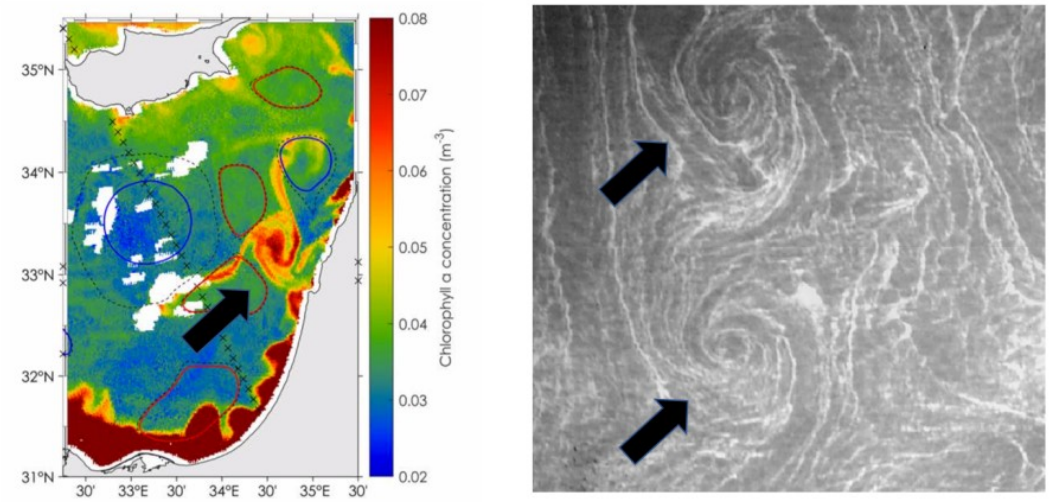

Figure 2 *Examples of eddy signature indicated with the black arrows on a chlorophyll image (left) and synthetic apertur radar (SAR) (right).*

<u>Outils et méthodologie:</u>

1. The first step of the work will be to provide a very large number of “images of eddy signature” to train the artificial neural network. The recent DYNED-Atlas data base will be used to locate a very large number of meso-scale eddies in the Mediterranean Sea during the 2000-2017 period. These eddies were first detected by the AMEDA algorithm form the AVISO surface velocity products. Then, a reliability index will be used to select only the detected eddies with a high-level accuracy on the altimetric maps. Therefore, we will guarantee that the eddy location and size are correct and we will be able to select the correct eddy area on the visible images (CHL, SAR) without any a priori on the eddy signature.

2. In a second step a visual inspection will be needed to build a true label set of few hundreds of images to test the efficiency and the accuracy of the various CNN models.

3. In a third step a global algorithm will be developed, including SST, CHL and SAR images, to validate the reliability of the AMEDA detection on the standard AVISO/DUACS products.

4. Links between the biogeochemical activity inside and outside the detected eddies could then be inferred from the surface signature of the eddies.

Références bibliographiques :

B.Levu, A.Stegner, T. Arsouze (2018) Angular Momentum Eddy Detection and tracking Algorithm (AMEDA) and its application to coastal eddy formation » J. Atmos. Oceanic Technol,doi:10.1175/JTECH-D-17-0010.1

E.Moschso, O.Schwander, A.Stegner, P. Gallinari (2019) A deep learning framework to detect oceanic eddies on SST images, ICASSP 2019. Submitted.

Redouane Lguensat, Miao Sun, Ronan Fablet, Pierre Tandeo, Evan Mason, and Ge Chen (2018) "Eddynet: A deep neural network for pixel-wise classification of oceanic eddies," in IGARSS 2018-2018 IEEE International Geoscience and Remote Sensing Symposium. IEEE, 2018, pp. 1764–1767.

Dongmei Huang, Yanling Du, Qi He, Wei Song, and Antonio Liotta (2017) "Deepeddy: A simple deep architecture for mesoscale oceanic eddy detection in sar images," in 2017 IEEE 14th International Conference on Networking, Sensing and Control (ICNSC). IEEE, 2017, pp. 673–678.

Compétences souhaitées :

This project would suit a student who wants to gain experience in artificial intelligence, in coastal oceanography and oceanic eddy detection in a Research environment. The student should have strong abilities in mathematics, problem solving and feal at ease with numerical computing. Good knowledge of matlab and/or python is required.
While initial training and guidance throughout the project will be available the student will be encouraged to work independently and show initiative in analysis methods and interpretation of results.