Proposition de stage

Machine learning algorithm for the prediction of ocean currents estimated from Sea Surface Temperature (SST) and Sea Surface Height (SSH) time series

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Mots-clés : Machine learning (ML), Deep Learning (DL), Numerical modeling, Remote sensing, Oceanic circulation

Context:

For several decades, a large variety of sensors has allowed to improve the knowledge of the state of Planet earth through remote sensing that provides a global coverage of the ocean with frequencies that vary with the phenomenon under study and the sensors. Ocean plays a major role in climate change thanks to air sea exchanges, heat transport via ocean circulation. So, significant parameters like SSH are available daily and the associated currents (U, V) can be estimated using the geostrophy from the gradient of SSH. A major problem in order to precisely study the oceanic circulation is to interpolate between the release of the remote sensing observations. Some products, including daily products, are provided by specialized portals such as the Copernicus Marine Resources service (https://resources.marine.copernicus.eu/) , which provides satellite observations as well as model data (Mercator). In the satellite products, the U and V components are not observations but the result of algorithmic calculations. The aim of the internship is to use the potential of Deep Learning (DL) algorithms to predict daily values of the current components between two releases of the remote sensing products.

Several studies using ML have been dedicated to model the ocean surface variables with success, showing the potential power of such methods. One can mention the reconstruction of SSH from satellite observation using convolutional neural network (Barth et al, 2020), Sea Level Anomaly interpolation using data driven methods (Lguensat et al, 2019) and CNN (Manucharyan et al, 2021; George et al, 2021), ML ocean simulations for climate modeling (Sonnewald and Lguensat, 2021). The problem of estimating ocean currents has been tackled by a large number of scientific studies which combined altimeter and SST satellite observations (Rio et al, 2016, Rio and Santoreli, 2018) or processed sequences of SST images (Bowen et al, 2002; Vigan et al, 2000; Kelly, 1989; Emery et al, 1986).

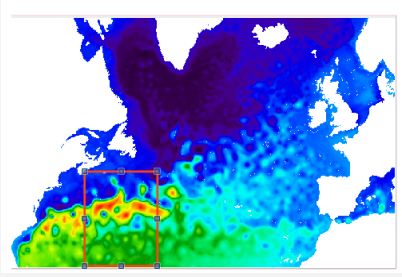

Figure 1.*The domain under study (Red Rectangle) and the SSH*

Proposed study:

A first experiment has shown that DL architectures can predict daily U and V with some confidence for a week in advance. The DL model will be first learned and tested on numerical oceanic model outputs which provide time series of SSH, SST., U and V. The aim of the internship is to improve the above preliminary results by using most recent developments of neural methodology (Thiria et all, 2021); therefore, to determine a new DL algorithm (New_DL). To assess the efficiency of New-DL its results will be compared against the geostrophy approximation

A second objective will be to use New_DL with the satellite data (SSH and SST) for the prediction of U and V and to test the accuracy of New_DL predictions

The experiments will be conducted on simulated ocean data in the Gulf Stream region (Fig. 1) which is the most energetic region of the North Atlantic Ocean (26°N, 45°N; 40°W, 65°W), the parameters (SSH, SST, U, V) being the outputs of the NATL60 ocean model based on the NEMO 3.6 code.

Prérequis

The master student should have prior knowledge of Python programming and some knowledge of neural network modeling with deep learning frameworks such as Keras/Tensorflow or PyTorch.

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Laboratoire concerné : LOCEAN, ESPRIT IA
Equipe de recherche concernée : (VARCLIM) :
Niveau du stage :M2
Master(s) où sera proposé le sujet : TRIED, WAPE, École d'ingénieur
Thème scientifique de l'IPSL concerné : *Downscalling, Deep Learning, remote sensing*
Durée du stage *: 6 mois (gratification de stage)*
Période : 01/04/2022 -→ 30/09/2022
Est-il prévu une thèse dans le prolongement du stage ? oui selon résultats