Offre de Stage IPSL 2022

(soutenu par le programme EUR IPSL-*Climate Graduate School)*

Titre du sujet de stage : Satellite Data – Numerical model synchronization at different scales

Description du sujet (1 page maximum) : voir document joint

Résumé en anglais (5 lignes) : The internship's aim is to explore the feasibility of obtaining higher resolution SSH issued from numerical models fields from coarser, satellite data & investigating the link with the satellite field at a higher resolution.

Responsable du stage (Nom/prénom/statut) : Béréziat Dominique MCF

Laboratoire concerné : LIP6 / SU

Adresse à laquelle a lieu le stage : 4 place Jussieu, Paris

Equipe de recherche concernée (si pertinent) ou autre participant à l'encadrement du stage:

Niveau du stage (Licence, M1, M2, internship) : M2

Licence ou Master(s) où sera proposé le sujet :

Thème scientifique de l'IPSL concerné : 4Dvar / Ocean

Durée du stage : 5 mois

Période : 1/3/22 → 31/8/22

Rémunération de l'ordre de 580 euros par mois

Est-il prévu une thèse dans le prolongement du stage ? oui

Satellite data - Numerical Model synchronization at different scales

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Context

For several decades, a large variety of satellite sensors has allowed us to dramatically improve the knowledge of the state of planet Earth and its potential evolution thanks to satellite remote sensed imagery. Satellite sensors provide global coverage of the ocean. These sensors are diverse both in terms of remote sensed technology and in geometrical sampling. They observe a multitude of geophysical parameters with various sampling, in space as in time.

They have permitted us to better know the ocean state such as **Sea Surface Temperature (SST)** with high-resolution radiometers such as the AVHRR sensors launched onboard meteorological satellites, **Sea Surface Height (SSH)** which is a good indicator of ocean circulation with altimeters (Topex, Poseidon and then Jason altimeters) that is retrieved in a coarser resolution.

These satellite sensors have contributed to detecting changes in the response of the ocean to global warming. The ocean is a major contributor to the climate state via air-sea exchanges (radiative processes, latent and contact heat fluxes), latitudinal heat transport via ocean circulation, climate regulator via the atmospheric CO2 uptake, and its enormous heat storage capacity. These ocean contributions to climate are related to ocean currents through a large variety of scales spanning from basin-scale down to sub-mesoscale [SKQS14, McW16]. Moreover, sub-mesoscale ocean currents may play an important role in structuring marine ecosystems [LFF+12]. These ocean data fields are therefore observed at different resolutions, but can also be calculated from physics-based models such as NATL60 at any resolution. These numerical dynamical models of oceanic circulation are fine-tuned, physics-informed predictive models that reconstruct the evolution of the ocean. The fields they produce are of high quality and consistent with the different physics governing the different scales at which we can observe the ocean. However, the higher their spatio-temporal resolution is, the more expensive they are to run and they can **present biases compared to observation**.

Objective

The internship's aim is to explore the feasibility of obtaining **higher resolution SSH issued from numerical models fields from coarser, satellite data & investigating the link with the satellite field at a higher resolution**.

Using deep learning techniques we can learn the link between the satellite-observed data and the model-inferred oceanic fields, as well as the inverse function. Investigating the degree this direct and inverse function is scale-invariant can be very beneficial to reconstructing realistic high-resolution oceanic fields, thus furthering our reconstruction and prediction of the oceanic circulation. We will specifically be exploring the recent literature on generative models based on diffusion [LDR+22, BSSE21].

The study will focus on the Gulf stream region (35°N, 55°W) where ocean currents and associated mesoscale dynamics are important, as seen below in the highlighted area pictured in Figure 1.

Skills

- Machine Learning, Deep learning, Image processing, Data Analysis

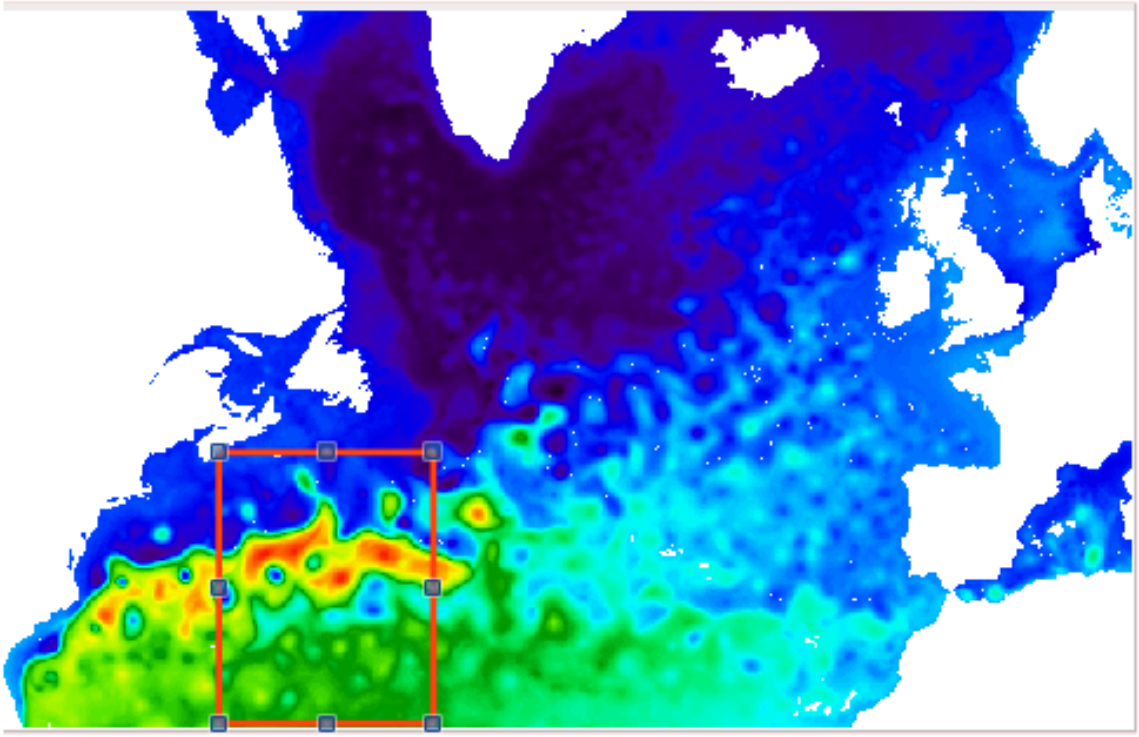

Figure 1: Studied region of the North Atlantic Ocean

- Deep learning programming, (mostly Pytorch)
- Interest for climate applications

Administrative stuff

The internship is funded by SCAI[1] for a duration of 5-6 months. It will be held in LIP6 laboratory (Sorbonne University) located in the center of Paris.

References

[BSSE21] Georgios Batzolis, Jan Stanczuk, Carola-Bibiane Schönlieb, and Christian Etmann. Conditional image generation with score-based diffusion models, 2021.

[LDR+22] Andreas Lugmayr, Martin Danelljan, Andres Romero, Fisher Yu, Radu Timofte, and Luc Van Gool. Repaint: Inpainting using denoising diffusion probabilistic models, 2022.

[LFF+12] M. Levy, R. Ferrari, PJS. Franks, A.P. Martin, and P. Rivière. Bringing physics to life at the submesoscale. *Geophys. Res. Lett.*, 39(14), 2012.

[McW16] J. C. McWilliams. Submesoscale currents in the ocean. *Proc. R. Soc. A*, 472, 2016.

[SKQS14] H. Sasaki, P. Klein, B. Qiu, and Y. Sasai. Impact of oceanic-scale interactions on the seasonal modulation of ocean dynamics by the atmosphere. *Nat. Commun.*, 5(5636), 2014.

[1] scai SORBONNE CENTER FOR ARTIFICIAL INTELLIGENCE