Satellite data - Numerical Model synchronization at different scales

5-6 month internship at Sorbonne University LIP6 lab (Jussieu, Center of Paris)
directed by D.Béréziat (LIP6), A. Charantonis (LOCEAN) and T.Archambault (LIP6)
contact: dominique.bereziat@lip6.fr

Scientific 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 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 detect 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 stockage 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 (Sasaki et al, 2014, McWilliams, 2016). Moreover, sub-mesoscale ocean currents may play an important role in structuring marine ecosystems (Levy et al, 2018).

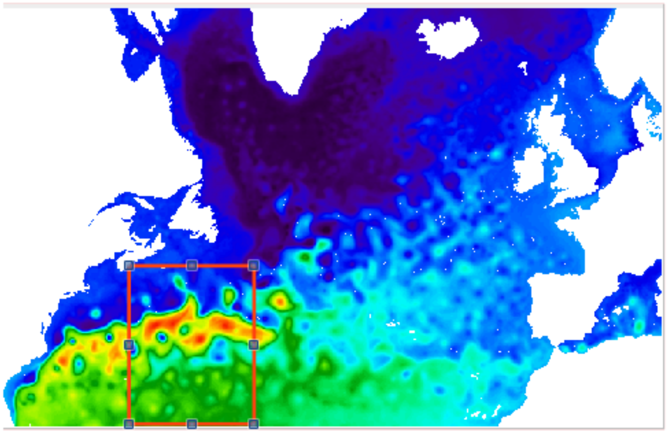
These ocean data fields are therefore observed at different resolutions, but can also be calculated from physics based models such as NATL60 at any resolution. These numerical dynamical models of oceanic circulation are fine tuned, physics-informed predictive models that reconstruct the evolution of the ocean. The fields they produce are of high quality and consistent to 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 ResNet Structures and explore the applicability of upscaling learned convolutions by expanding them spatially in higher dimensions.

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:



References

Sasaki, H., Klein, P., Qiu, B. & Sasai, Y., 2014. Impact of oceanic-scale interactions on the seasonal modulation of ocean dynamics by the atmosphere. Nat. Commun. 5, 5636.

McWilliams, J. C., 2016. Submesoscale currents in the ocean. Proc. R. Soc. A 472, 20160117. 10.

Levy M., Ferrari R., Franks PJS., Martin A.P., Rivière P., 2012. Bringing physics to life at the submesoscale. Geophys. Res. Lett. 39, L14602.

Skills :

- Machine Learning, Deep learning, Image processing, Data Analysis
- Python programming, Keras is a plus
- Interest for climate applications