A stochastic adventure for the ocean

Master research internship proposal

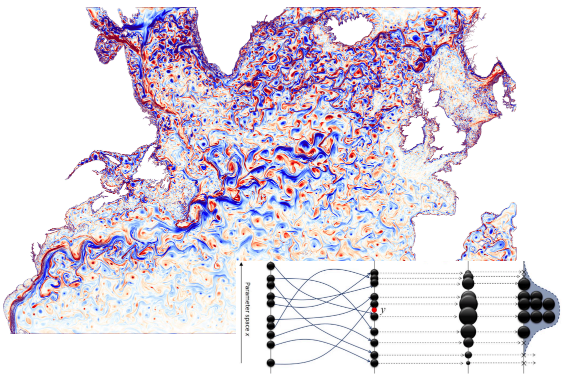
Scientific advisors: Arthur Vidard (arthur.vidard@inria.fr)
Elise Arnaud (elise.arnaud@univ-grenoble-alpes.fr)
Etienne Mémin (etienne.memin@inria.fr)
Websites : https://team.inria.fr/airsea/en/
http://www.irisa.fr/fluminance/indexFluminance.html

Functional area: Laboratoire Jean Kuntzmann
Inria Project Team AIRSEA
IMAG Building, 700, avenue centrale
38401 Saint Martin d'Hères

Keywords: data assimilation, particle filter, stochastic parameterisation and P.D.E.s.

Context. One of the many achievements of computer aided simulations has been the sharp improvement in the human prediction capabilities of weather and climate, with undeniable benefits for society: agricultural planning, extreme weather preparedness, mitigation of climate change effects, etc. The quality of the simulations rely on the ability to acquire data about the present state and the past state and to assimilate these data in the numerical model to make reliable predictions. This is referred as data assimilation.

Goals. Data assimilation can be seen as the art of compromise. It refers to a large variety of methods that allow to combine all sources of information available about a given system : mathematical equation (physical laws), observations (measures of reality) and error statistics.



Representing properly physical model uncertainties is a tricky problem, and new approches using stochastic parameterisation have been recently derived [1]. They lead to consider non Gaussian statistics, thus making impossible the use of classical ensemble data assimilation methods, which rely heavily on the Gaussian hypothesis.

Particle filters are theoretically-validated Monte-Carlo based techniques that do not require Gaussian assumptions on the model. In that framework, the data assimilation problem is written as a large-scale Bayesian inverse problem. It requires the estimation of the probability distribution of the state variables, at a given time, conditioned on all the previously observed measurement data. Particle filter algorithms receive a growing attention from the data assimilation community [2]. They consists in sampling the state space in places where the data could appear. However they perform poorly for large state space dimension [2,3].

The goal of this internship is to combine stochastic parameterisation of model uncertainty with particle filter. Evidences show that the properly defined error representation will allow for a better exploration of the state space, and thus is a possible way to address the dimension issue. After a literature study, the intern will test the feasibility of the idea on a test case that implement a simplified 2D ocean model at coarse resolution in a double gyre setting. This configuration is meant to represent an idealized North Atlantic circulation (Gulf Stream).

This internship can lead to a PhD, where an application to realistic ocean models is foreseen. This work is part of an ongoing collaboration with Imperial College (London, UK) and Ifremer.

Prerequisites. Applied math skills (optimisation, numerical analysis, probability / statistics) and programming skills (Matlab, python, C or Fortran)

Bibliography

[1] V. Resseguier, E. Mémin, B. Chapron (2017): Geophysical flows under location uncertainty, Part I: Random transport and general models. Geophysical and Astrophysical Fluid Dynamics, 111(3):149-176.
[2] P.J. van Leeuwen. Data Assimilation for the Geosciences. chapter Particle filters for the Geosciences. Oxford University Press Blue Book Series, 2014.
[3] E. Arnaud: Lecture notes in inverse methods and data assimilation. https://team.inria.fr/airsea/files/2018/11/Poly_InvMet-M2.pdf