Travelling with turtles

Proposal for a research Master's internship, applied mathematics

Supervision: Elise Arnaud (elise.arnaud@univ-grenoble-alpes.fr)
Arthur Vidard (arthur.vidard@inria.fr)
Philippe Gaspar (philippe.gaspar@mercator-ocean.fr)
Sites : https://team.inria.fr/airsea/en/
http://www.mercator-ocean.fr

Location: Laboratoire Jean Kuntzmann
Equipe projet Inria AIRSEA
Batiment IMAG, 700, avenue centrale
38401 Saint Martin d'Hères

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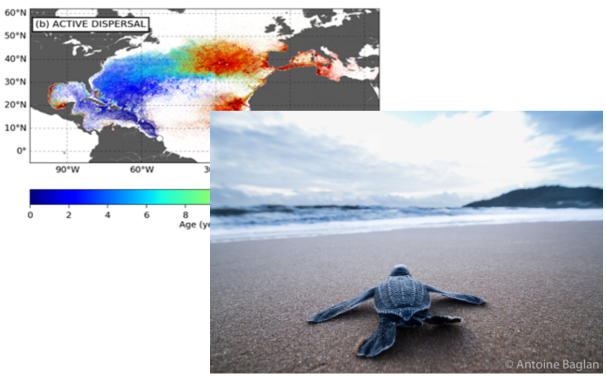
Context. Most, if not all, numerical simulations depend on a set of approximatively known parameters. It is often necessary to adjust them as best as possible in order to make the simulation realistic. This step, called parameter estimation, encompasses a multitude of methods. They generally consist of comparing in a more or less sophisticated way the result of the simulation and the observations of the simulated system. Among the methods used is the particle filter (or sequential Monte Carlo method) [1] which uses a set of particles (instances of the simulation model) to represent the distribution *a posteriori* of a given stochastic process, taking into account noisy and/or partial observations. The numerical model can be non-linear and the distributions of the initial state and the observation noise can take any required form, which is a significant advantage over most other methods. However, particle filters are not very efficient when applied to very high dimensional systems.

Goal. During this course we propose to apply the particle filter for parameter estimation for the numerical model STAMM[1] [2]. This model estimates the movements of sea turtles according to sea currents and the quality of the water masses in which they are found. In addition to these two elements, which are given by large-scale oceanic general circulation models, STAMM's good behaviour depends on a small set of parameters: the habitat function (3 or 5 parameters), which defines the comfort in which the turtle finds itself, as a function of temperature and the presence of plankton; the swimming speed, which depends on the individual; and a dispersion law, which represents the fact that the turtle does not necessarily go directly in the right direction to improve its habitat. According to the turtle's age, a parameter will have to be added to model their tendency to return to their birthplace to lay their eggs in their turn.



This type of problem thus lends itself well to the application of a particule filter. We also have a large data bank representing several thousands of trajectories of loggerhead turtles, which will make it possible to carry out this study within a realistic framework. After an appropriation of the subject and a bibliographical research, This internship will require implementing the chosen method and studying its effectiveness. If time permits, the subject can be opened up to the estimation of parameters in the presence of uncertainty, with the addition of taking into account the uncertainties resulting from forcing by the oceanic general circulation model.

This course may lead to a PhD, in which the possibility of using successive turtle positions to reduce uncertainties in the characteristics of the fields predicted by the ocean general circulation model will be studied.

Prerequisite. Skills in applied mathematics, (optimisation, numerical analysis, probability/statistics) and programming skills (Matlab, python, C or Fortran)

Bibliography.

[1] E. Arnaud: Lecture notes in inverse methods and data assimilation. https://team.inria.fr/airsea/files/2018/11/Poly_InvMet-M2.pdf

[2] Gaspar P, Lalire M (2017) A model for simulating the active dispersal of juvenile sea turtles with a case study on western Pacific leatherback turtles. PLoS ONE 12(7): e0181595. https://doi.org/10.1371/journal.pone.0181595

[1] Sea Turtle Active Movement Model