# Master 2 internship in Brest, France : "Spatio-temporal interpolation of ocean surface currents using AIS signals from vessels"

Clément Le Goff (E-Odyn) and Pierre Tandeo (IMT Atlantique)

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## 1 Context

Marine traffic is constantly increasing and the concentration of vessels in transit in certain parts of the world allows a qualification or a precise quantification of geophysical phenomena such as oceanographic currents, wind or waves. This connection between ship traffic and geophysics is not new and the Gulf Stream was discovered by B. Franklin by examining the logbooks of the ships containing information on their drift. This detailed analysis of ship logs, although it has been ongoing, has been forgotten in the face of the rise of satellite altimeters capable of detecting variations in ocean heights and inferring some of the main ocean currents.

In this context, Eodyn today systematically uses AIS (Automatic Identification System) messages and cleverly hijacks their primary function of surveillance and safety by bringing up-to-date techniques of Dead reckoning navigation (Le Goff et al, 2021). The precise location of ships and the density of traffic offered by AIS data flows give a new horizon to this technique (see Fig. 1). From the AIS data, an inverse problem is resolved in order to estimate the ocean surface currents (see Fig. 2). The goal of this internship is to interpolate, in both space and time, those current estimates from AIS.

Keywords: marine traffic, AIS, surface currents, statistical modelling, uncertainties, minimization

## 2 Methodology

Optimal Interpolation (OI) is the classic way to interpolate data in a regular spatio-temporal grid. In its basic formulation, OI corresponds to a global inversion of the system, taking into account the whole set of observations, with temporal and spatial correlation structures. However, the global inversion is not possible due to the large amount of grid points and time steps. Thus, in practice, the global inversion is divided into sub parts to reduce the computational cost. But merging the independent results of the different sub parts is not optimal and creates artefacts in the interpolation fields.

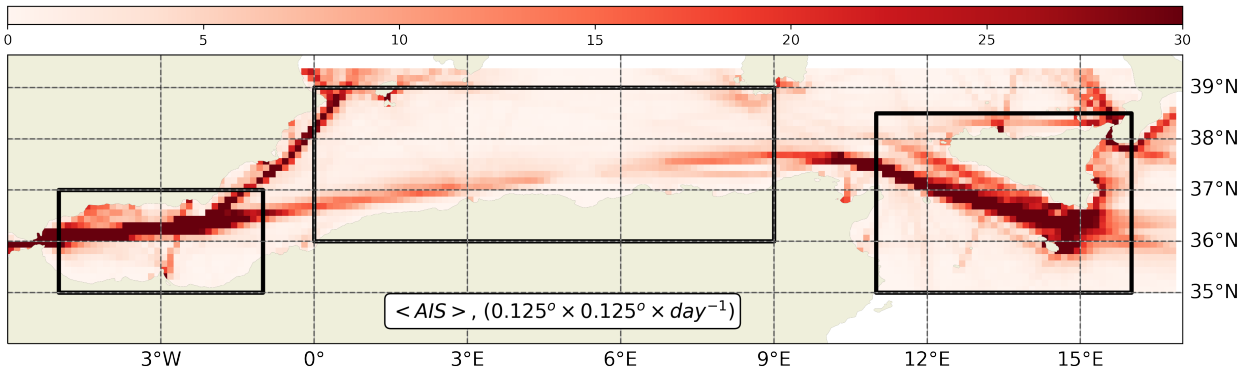


Figure 1: Mean density of AIS messages per day in a square of $0.125^o$ in the Mediterranean sea. Data obtained from ORBCOMM.

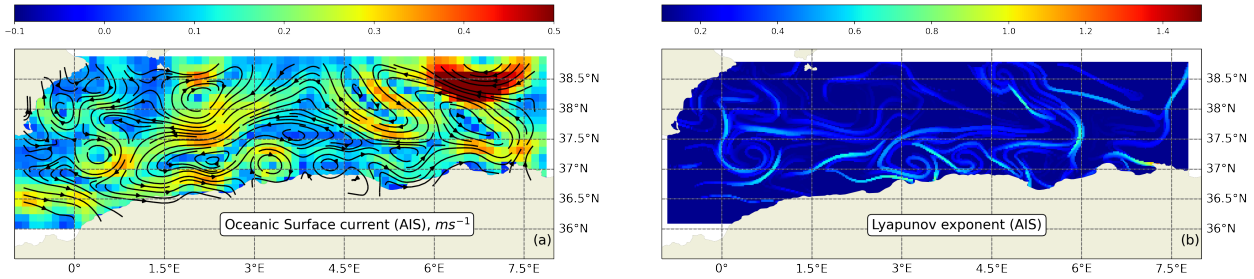


Figure 2: Example of oceanic currents inferred from the AIS data messages and the associated Lyapunov exponents.

The Kalman Filter is an alternative which is able to mimic the optimal interpolation, without working in independent sub-parts. This method is sequential (i.e., it works iteratively between two consecutive time steps) and thus considerably reduces the computational time. It is also well designed to study separately the spatial and temporal variations. Finally, statistical methods can be coupled with the Kalman Filter to estimate the errors coming from the observations and the dynamical model inferred from the data (Tandeo et al, 2020).

# 3 Objectives of the internship

The first task will be to implement the classic optimal interpolation, the Kalman Filter, and to compare them using artificial data. In a second task, an estimation algorithm will be implemented to tune the parameters of the Kalman filters, including error covariance matrices and linear dynamical operators. In a third task, those methodologies will be tested on real datasets of surface currents retrieved from AIS signals.

# 4 Expected skills of the candidate

- good skills in coding (Python)
- background in applied mathematics
- interest for oceanography or environmental data

# 5 Location of the internship

This Master internship will take place at IMT Atlantique, an engineering school in Brest, France. Another Master internship will take place at SHOM, the French oceanographic service of the marine, during the same period. Regular meetings will be organized between IMT Atlantic, SHOM, and E-Odyn.

# 6 Period and remuneration

The internship will start on April and finish on September 2023 (6 months). The internship will be remunerated of 600 euros per month.

# 7 Contacts


- Pierre Tandeo (pierre.tandeo@imt-atlantique.fr)
- Clément Le Goff (clement.legoff@e-odyn.com)
- Stéphane Raynaud (stephane.raynaud@shom.fr)

# References

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