Proposition de stage de Master 2/école d'ingénieurs 2022-2023

Direct in situ observations of particle flux: new perspectives from in situ imaging data

Responsables du stage: Tristan Biard *(Maître de conférences – LOG UMR 8187)*, Enrico Calzavarini *(Maître de conférences - Univ. Lille, ULR 7512 - Unité de Mécanique de Lille - Joseph Boussinesq)*, Laget Manon *(Doctorante – LOG UMR 8187)*
Lieu du stage : Laboratoire d'Océanologie et Géosciences (UMR 8187) – Wimereux - France

Context: In modern oceans, photosynthetically produced organic matter is exported from the surface to the deep ocean, a process described as the Biological Carbon Pump. One of its key mechanisms is the gravitational settling of particles (e.g., fecal pellets, marine snow), which is influenced by the nature of the particles (e.g., size, density, the presence of ballasting minerals) and thus their sinking speeds. Knowing the magnitude of carbon export, and subsequent sequestration in deep sea sediments, therefore requires knowing the speed at which particles can travel to the deep ocean. Sinking speeds have often been estimated according to Stokes' Law, but it assumes that particles are perfect spheres, which is almost never the case in marine environments. Thus, measuring the speed of sinking particles directly in their environment would help to refine carbon flux estimations. To reach this objective, we use imaging techniques, a growing field of ocean observation (Lombard et al., 2019). We developed the VisuTrap system, which is composed of an *in situ* camera UVP6 (Picheral et al., 2022) mounted in a cylindro-conic sediment trap. The trap aims at isolating a water mass so the camera can record the tracks of the sinking particles. Then, images are

Figure 1- Visutrap (bottom left) deployment off California

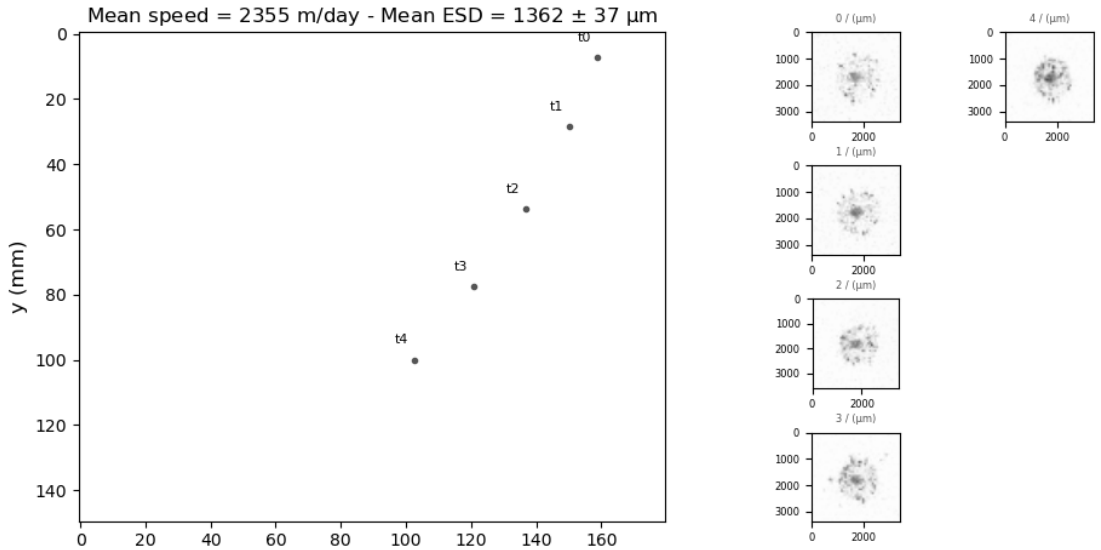

Figure 2- Example of in situ sinking trajectories. Images on the right panel represent the imaged organism at each time step (Time 0 to Time 4). Mean sinking speed and the corresponding organism size are indicated on the top left part.

processed to recover the tracks and calculate the speed of the particles. This method allows to have an unprecedented dataset of sinking particles, which needs to be linked to the properties of the particles and of the water mass surrounding them.

Objectives: 1) Characterize the relations between sinking speed of a broad range of marine particles (both organic and inorganic) and multiple morphometric characteristics.
2) Determine if sinking speeds can be explained by theoretical laws (e.g., Stokes or preferential sweeping in turbulent flows).
3) If times allow, reconstruction of carbon fluxes will be carried using the newly constrained sinking speed estimates.

Methods: The candidate will have access to an extensive imaging dataset from 3 oceanographic cruises recorded in 2021-2022, coupled with hydrographic measures and contextual data. He/she will be trained to ocean biogeochemistry concepts and will handle data processing to analyze the tracks of the sinking particles.

Resources available: This position will be based at the Laboratoire d'Océanologie et Géosciences (LOG), Wimereux. The candidate will integrate the ECOP2 research team, a multidisciplinary team of marine ecologists and biologists, where he/she will be supervised by Tristan Biard and Manon Laget, who work on the biological carbon pump. He/she will exchange regularly with Enrico Calzavarini at Unité de Mécanique de Lille - Joseph Boussinesq (UML) ULR 7512, Univ. Lille.

Required skills: We are looking for an enthusiast candidate with at least an intermediate-level in programming (Python language preferred, or R) as he/she will spend most of his/her time analyzing large data files. Candidates eager to discover the fascinating world of marine environment and looking to apply their coding skills to new original datasets are particularly welcome. Knowledge in fluid dynamics and/or chemical oceanography will be appreciated (yet not mandatory – just expect some of these topics to pop up during the internship!).

Interested candidates should send an email to Tristan Biard (tristan.biard@univ-littoral.fr), Enrico Calzavarini (enrico.calzavarini@polytech-lille.fr) and Manon Laget (manon.laget@univ-littoral.fr) with the subject line: M2_sinking_speeds, and include the following:

- Cover letter of 1 page (with a brief summary of the candidate's academic experiences and research goals)
- Curriculum vitae

Literature:

- Lombard, F., Boss, E., Waite, A. M., Vogt, M., Uitz, J., Stemmann, L., ... & Appeltans, W. (2019). Globally consistent quantitative observations of planktonic ecosystems. *Frontiers in Marine Science*, *6*, 196.
- Picheral, M., Catalano, C., Brousseau, D., Claustre, H., Coppola, L., Leymarie, E., ... & Stemmann, L. (2022). The Underwater Vision Profiler 6: an imaging sensor of particle size spectra and plankton, for autonomous and cabled platforms. *Limnology and Oceanography: Methods*, *20*(2), 115-129.
- Berk T. & Coletti F. (2021). Dynamics of small heavy particles in homogeneous turbulence: a Lagrangian experimental study. *Journal of Fluid Mechanics 917.*