M2 Research Internship: Micrometeorology and optimal exploration-exploitation of thermals using 3D paragliding track data.

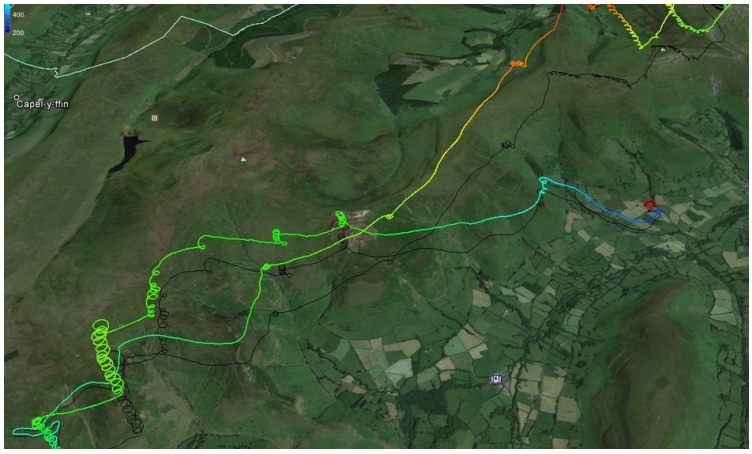
Laboratory name: Laboratoire d'Hydrodynamique, LadHyX
CNRS identification code: UMR CNRS 7646
Internship location: Ecole Polytechnique, Palaiseau.
Thesis possibility after internship: YES
Funding: YES

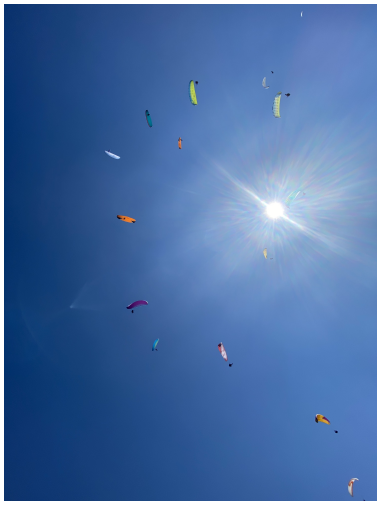
Supervision: Alexandre Darmon & Michael Benzaquen (X)
Antoine Viennot (Freedom Parapente)

Email: michael.benzaquen@polytechnique.edu

To gain altitude in the atmosphere, birds, gliders, paragliders and handgliders exploit thermal updrafts or *thermals* [1-3]. These are cyclic columns of rising air resulting from the uneven solar heating of the ground surface, which in turn warms the air directly above it, and initiates atmospheric convection (very much like a pot of boiling water). Of little interest for larger and faster aircrafts, thermals, and more generally micrometeorological phenomena, have drawn much less attention from the scientific community than their larger scale counterparts. While most know-how is of empirical nature, little is known on a quantitative level. How far are these columns from each other? How regular is their spatiotemporal structure? How is it affected by the season, time of day, cloudiness or ground topology?

The aim of this project is twofold. First, the idea is to use such light aircrafts as smart atmospheric probes to build a statistical model of the multi-thermal spatiotemporal structure and identify the relevant parameters that affect its features. To do so, we shall use large numbers of 3D paragliding tracks in different conditions and places (extracted from altivario GPS[1] manufacturer's databases), together with topological and satellite imaging data. Second, we wish to focus on the optimal exploration-exploitation strategies, using 3D tracks from paragliding races. Indeed, as a pilot aiming at travelling the longest possible distance before landing, one needs to find the right balance between (i) an individualistic strategy using one's knowledge (ground topology and colour, cumuliform clouds) to find the next nascent thermal, with the risk of missing out, and (ii) the collective strategy consisting in following other pilots that materialise where the thermals are located, with the risk of getting there too late.[2]





The internship will be held at the Laboratoire d'Hydrodynamique de l'X in close connection with Henri Montel and his team at Freedom Parapente (Puy de Dôme) to confront our findings and learn from their experience. Good numerical and data analysis skills are advised.

[1] Cone (1962). Thermal soaring of birds. American Scientist 50(1), 180.
[2] Akos, Nagy, Leven, & Vicsek (2010). Thermal soaring flight of birds and unmanned aerial vehicles. Bioinspiration & biomimetics 5(4), 045003.
[3] Harel, Horvitz & Nathan (2016). Adult vultures outperform juveniles in challenging thermal soaring conditions, Scientific Reports 6, 27865.

[1] Flight instrument carried by most seasoned pilots.
[2] As the common saying goes "alone one goes faster, together we go further".