

Mapping atmospheric convection from paragliding trajectories

Pilots as a distributed sensor network

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Project at a Glance

Can thousands of recreational flights become an observatory of atmospheric convection? This internship will use large-scale paragliding trajectories to investigate the structure and dynamics of thermal updrafts. Combining atmospheric physics, trajectory analysis and statistical inference, we will explore what nearby pilots can reveal collectively about an invisible, evolving flow, while accounting for the selective way they explore it.



Figure 1: Illustration of paragliders circling within convective updrafts. Image generated by ChatGPT.

Project Description

Thermal updrafts transport heat, moisture and momentum through the atmosphere, yet their fine-scale structure remains difficult to observe. Paragliders offer an unusual opportunity: by circling within rising air, pilots record trajectories that contain information about the atmospheric structures they exploit. Our recent work has demonstrated the potential of these records as convection measurements [1], while our analysis of soaring transport provides methods for distinguishing gliding, searching and climbing [2]. The next step is to move from statistics of individual climbs to the reconstruction of atmospheric structures sampled by several pilots.

The internship will begin with an existing archive of 120,000 flights and 1.5 million climbing segments over France [1]. The student will identify well-sampled sites and days, synchronise nearby trajectories, and examine repeated encounters with candidate updrafts. Building on methods developed for estimating wind and convection from soaring birds [3, 4], we will investigate which properties can be recovered from flight geometry and climb rates: horizontal drift, vertical profiles of updraft strength, spatial coherence and persistence. A central question will be how much information is gained by combining several flights rather than analysing each independently.

The challenge is to separate atmospheric motion from the response of the aircraft and pilot. A recorded climb rate is not the vertical air velocity, and a circling radius is not necessarily the radius of a thermal. Aircraft sink rates, turning manoeuvres, altitude errors and terrain-induced lift must therefore be considered explicitly. Simple physical models and tests on simulated trajectories will help identify what the observations actually constrain. Reconstructions will also be evaluated on flights withheld from estimation; meteorological reanalysis will provide large-scale context, not ground truth for individual thermals.

A complementary extension will examine how collective behaviour affects the quality of this distributed observatory. Pilots may follow one another into strong updrafts, improving local coverage while leaving other regions unexplored. Inspired by work on collective sensing in soaring birds [5], we will ask whether groups provide complementary measurements or mostly repeat the same information. Comparisons between isolated and grouped flights will help assess these sampling effects, without assuming that correlated movements alone demonstrate social influence.

The objective here is not a black-box prediction of climbing performance, nor a complete reconstruction of the atmosphere from sparse tracks. It is to establish which physical properties of convection can be inferred reliably from opportunistic trajectories, at what resolution and with what uncertainty. Even a local reconstruction, together with a clear account of its limitations, would provide a foundation for using recreational flight archives as an atmospheric observing system.

References

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