INTERNSHIP PROPOSAL

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Internship location: LPENS (24 rue Lhomond, 75005, Paris)

Thesis possibility after internship: YES
Funding: POSSIBLY

Cloud patterns, convective self-aggregation and global warming

The aim of the internship and the PhD thesis is to investigate the effect of entrainment, preconditioning and convective self-aggregation on cloud patterns, in connection to global warming issues, using a combination of field analysis, controlled laboratory experiments, theory and numerical simulations.

Context — Anthropogenic global warming stands as one of the paramount crises confronting our society. Clouds hold a pivotal position within Earth's climate system: firstly, they govern precipitation patterns, influencing water resources and agricultural outcomes; secondly, they exhibit radiative effects that can change sign depending on the cloud geometry; thirdly, the degree of clustering of clouds significantly impacts the mean moisture and radiative properties of a given area, even for a given cloud fraction. The uncertainty surrounding climate sensitivity—defined as the global temperature rise associated with a doubling of CO_2 concentration in the atmosphere compared to pre-industrial levels—largely stems from the response of clouds to warming. Warm trade wind clouds exert a significant influence on the global planetary albedo despite covering a small fraction of the planet, and deep convective clouds impact both the atmospheric energy balance and circulations, as well as precipitation. The behavior of these clouds under global warming thus matters for the regulation of the Earth's energy budget and hydrological cycle. Satellite observations indicate that the shallow and deep clouds associated with atmospheric convection tend to cluster, forming a diverse array of spatial organizations or patterns at the mesoscale. Idealized models have suggested that the mesoscale organization of convection could occur spontaneously—a phenomenon termed 'convective self-aggregation'—impacting the large-scale atmospheric state and precipitation extremes. Despite their central role, cloud patterns are not well understood and constitute an active field of research and debate.

Objectives — To address the organization of convection and the formation of cloud patterns, the proposal starts with two central questions. How does convection self-organize when an unstable turbulent layer is capped by a stably stratified layer? What controls the survival time against evaporation and the buoyant ascent dynamics of active clouds? The second problem requires a detailed understanding of the heterogeneities of turbulent mixing around the fractal edges of clouds in the ascending phase, i.e., the entrainment of the external fluid and thus humidity, cold, and nuclei. The environment of the clouds plays a key role in their ascending dynamics generated by the latent heat released during the nucleation of droplets. Its structure arises from two concurrent processes: long-term pre-conditioning, linked to radiative effects and overturning circulation, and the modification of thermofluidic fields by active clouds that stop their ascent and evaporate, releasing their thermal energy, nuclei, and humidity. We thus hypothesize that this local memory of previous clouds plays a key role in understanding cloud patterns as an effective spatio-temporal interaction.

Condensed Matter Physics: NO Soft Matter and Biological Physics: YES
Quantum Physics: NO Theoretical Physics: YES