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PhD opportunity (2027 start): Unravelling turbulent mixing through exascale simulations

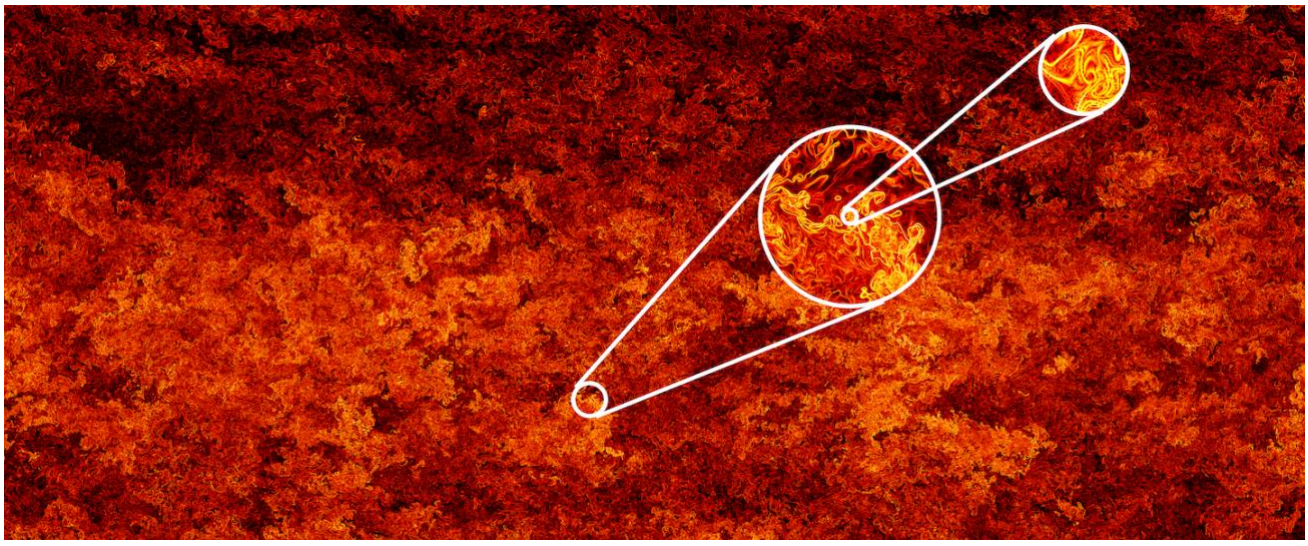
Supervisor: Dr Adrien Lefauve
Institution: Imperial College London
Department: Civil and Environmental Engineering and Grantham Institute – Climate Change and the Environment, South Kensington Campus

Project summary: How does turbulence mix the climate, and how can we predict its effects? Density differences caused by temperature or salinity shape mixing throughout the ocean and atmosphere, influencing the transport of heat, nutrients and pollutants. Yet the small-scale, processes responsible for mixing remain difficult to represent in environmental models.

This project will explore exceptionally detailed simulations of stratified turbulence generated by the international **STRATA collaboration** on Frontier, an exascale supercomputer at Oak Ridge National Laboratory in the USA. These datasets offer an opportunity to investigate mixing across an extraordinary range of scales and develop new connections between fluid mechanics, applied mathematics and data science (**video**). The research could address several connected questions:

- **Turbulent structures:** Which flow features, such as thin density interfaces and overturning instabilities, control mixing, and how can we identify them in vast datasets?
- **Extreme events:** How much mixing occurs through rare, intense events, and what determines where and when they develop?
- **Mixing regimes:** Do common patterns emerge as turbulence becomes more intense, or do different physical processes require distinct models?
- **Physics-informed data analysis:** How can machine learning and carefully designed sampling reveal important dynamics while retaining rare events?
- **Connecting simulations and observations:** Can these highly resolved simulations improve estimates of mixing from sparse measurements and inform models?

The precise focus will be developed around the student's interests and strengths. Methods could combine analysis of existing simulation datasets, theoretical modelling, scientific machine learning and comparison with observations. The project collaborate with Imperial's Department of Mathematics, York University (Canada) and the National Oceanography Centre.



You will join Imperial's Department of Civil and Environmental Engineering and the Grantham Institute, benefiting from a world-leading education, professional development and research environment in environmental fluid mechanics, climate change and sustainability. You will also engage with an international research collaboration, with Imperial's **Hydrodynamics Laboratory** and develop industry-relevant skills in scientific computing, machine learning and large-scale data analysis.

Funding: There is currently no dedicated funding attached to this opportunity. Suitable candidates may be supported in applying for **departmental or Imperial scholarships**, subject to eligibility, availability and competitive selection. Applicants are also encouraged to explore external funding, including scholarships from their home country, such as **LPDP for Indonesian applicants**. Please explain your proposed funding route when enquiring. We cannot consider applicants without a realistic funding route.

Candidate profile: We welcome applicants with:

- A strong academic record in applied mathematics, physics, engineering, oceanography or a closely related discipline, including a Master's-level qualification.
- An interest in fluid mechanics, turbulence and the physical processes of environmental flows.
- Experience in scientific programming and data analysis, e.g. using Python, Julia or MATLAB.
- Strong analytical, communication and organisational skills, and the motivation to work independently and across disciplines.

Previous experience in numerical simulation, high-performance computing or machine learning is desirable but not essential.

How to express interest: Please email me at **a.lefauve@imperial.ac.uk**, using the subject line "PhD enquiry: Exascale stratified turbulence", and attach the following in one PDF under 10 MB:

- **A short cover letter, no more than one page**, explaining which research questions interest you, why your background is suitable, and relevant research, programming or field experience.
- **Your CV.**
- **Undergraduate and Master's transcripts**, including the grading scale where available.
- **A clear proposed funding route**, including any specific scholarship eligibility and application deadlines.
- **Details of two academic referees**, who will not be contacted without prior notice.

Include English-language test results if already available. A formal application through Imperial's admissions system is not required at this initial stage.

Please address the project specifically. Generic enquiries without the requested information will not receive a response.