IMPERIAL

Department of Civil and Environmental Engineering

PhD Post in Environmental Fluid Mechanics (Imperial College, South Kensington campus)

Project title: Exploring stratified turbulent mixing by shear instabilities in coastal waters

Supervisor: Dr Adrien Lefauve

Description:

Background – Water will likely become the gold of the 21st century due to its central role to life, health, and economic growth and its increasing scarcity. Estuaries are particularly interesting, being critical transition and exchange zones between freshwater and marine environments, which often host great cities, including London. Sea-level rise and pollution put estuaries and their essential services under pressure. Understanding the transport and mixing of freshwater and denser saltwater layers is critical to engineering efforts to mitigate climate change.

Scientific question – This project will tackle a fundamental question in environmental fluid mechanics: how does turbulence mix density-stratified (i.e. layered) fluids? The scientific challenge is rooted in the vast spectrum of length scales over which energy is distributed and exchanged, preventing direct computations [1]. This project will focus on the fascinating lifecycle, turbulent energy cascade, and mixing of large-scale shear instabilities, which are the primary structures responsible for mixing in estuaries. Observational evidence in a salt-stratified estuary challenges our understanding of mixing based on computational models [2]. This project will leverage recent state-of-the-art field data (figure 1) to drive a paradigm shift in estuarine mixing.

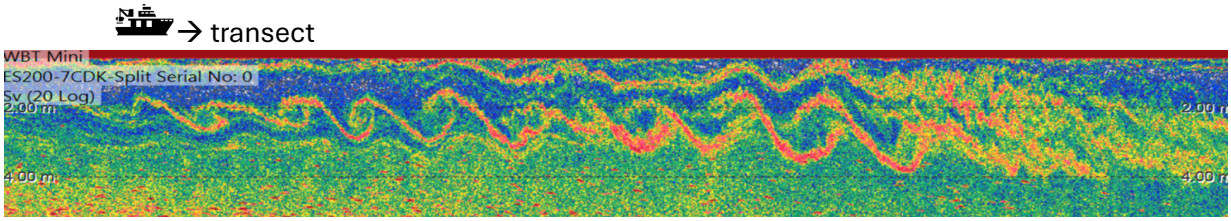

Figure 1: Acoustic measurement in an estuary revealing the structure of mixing by shear instability.

Methodology – You will perform mathematical analysis of observational data, including multibeam echograms (acoustic backscatter), which provide a high-resolution picture of underwater turbulent mixing [3]. You will use these analyses to formulate new fluid mechanical models bridging the challenging scale spectrum. The goal will be to develop hypotheses and design a new fieldwork campaign to gather complementary data. There will be an opportunity to perform fieldwork in the USA in collaboration with the Applied Ocean Physics & Engineering Department of the world-leading Woods Hole Oceanographic Institution. The ideal outcome will be to distil the new mixing physics into practical reduced-order models called parameterisations [4], to improve the coastal numerical models used to address sustainability challenges.

Skills gained – This PhD is suited to a student who seeks to gain valuable multi-disciplinarity skills in fluid mechanics and coastal oceanography. These skills include modelling physical systems (turbulence, parameterisations of numerical models), data science and management (advanced image analysis, handling large environmental datasets) and, potentially, technical fieldwork and training, depending on the student's interests. These skills align with the 'most wanted skills' for environmental science identified by the UK Natural Environment Research Council, guaranteeing exciting post-PhD career prospects in academia or industry.

Required:

- First-class degree (or internationally equivalent) in engineering, physics, applied mathematics or a closely related discipline, and familiarity with fluid mechanics.
- Masters-level degree
- Proficiency in scientific programming and data analysis (e.g. MATLAB, Python, Julia)
- Excellent English writing and communication skills (e.g. IELTS 7.0 or TOEFL 100 overall).
- Evidence of strong critical thinking, organisation, time management and independence.
- High level of motivation for mathematical modelling and physical understanding of environmental flows, and for data-intensive and multi-disciplinary research.

Desired but not essential:

- Research experience and high-quality outputs.
- Knowledge of hydraulics, turbulence theory and modelling, physical/coastal oceanography, acoustics, instrumentation and data acquisition.

Funding:

The studentship will provide funding for tuition fees at the level of Home (UK) students and a tax-free stipend at the standard UKRI London rate (£21,237 pa for 2024/25). The funding can also be used to partially support an international student, combined with other scholarships. For further details on scholarship competitions and eligibility, see this page.

How to apply:

Enquiries and applications should be made directly to Dr Adrien Lefauve (lefauve.adrien@gmail.com) with the following materials in a single PDF file (under 20 MB):

- Cover Letter explaining your motivation and suitability by addressing the requirements, including details of any prior research experience (if any)
- CV
- Undergraduate and masters transcripts with grades and class rankings (if any)
- English testing results, i.e. IELTS or TOFEL (if any).
- Details of two academic referees (including name, affiliation, and email address).

Application via the Imperial College Registry is not necessary at this stage.

Review of applications will begin immediately and continue until the position is filled.

References:

[1] Dauxois, T., *et al*. 'Confronting grand challenges in environmental fluid mechanics'. *Physical Review Fluids* **6**, 020501 (2021)

[2] Geyer, W. R., Lavery, A. C., Scully, M. E. and Trowbridge, J. H. 'Mixing by shear instability at high Reynolds number'. *Geophysical Research Letters* **37**, 2010GL045272 (2010)

[3] Lavery, A. C., Geyer, W. R. and Scully, M. E. 'Broadband acoustic quantification of stratified turbulence'. *Journal of The Acoustical Society of America* **134**, 1, 40–54 (2013)

[4] Umlauf, L., & Burchard, H. 'A generic length-scale equation for geophysical turbulence models.' *Journal of Marine Research,* **61**(2), 235–265 (2003)