LIFD
Leeds Institute for
Fluid Dynamics

Programme

Wednesday 26th April 2023

16:00pm– 19:00pm

LEEDS INSTITUTE FOR FLUID DYNAMICS

Time	**Activity**	**Presenter**
16:00-16:10	Leeds Institute for Fluid Dynamics welcome	Steve Tobias, University of Leeds
16:10-16:25	Essentially Lagrangian simulation of turbulence, mixing and phase transitions with the Ellipsoidal Parcel-in-Cell model	Steven Boeing, University of Leeds
16:25-16:40	Transient Models for Assessing Airborne Infection Risk in Naturally Ventilated Hospital Wards.	Alexander Edwards, University of Leeds
16:40-16:55	COVID-19 Pathogen Transport in naturally ventilated bus.	Julie Frank, University of Leeds
17:00- 18:00	Keynote talk: “The fluid mechanics of STAMP collecting: what SID tells us”	Paul Linden, University of Cambridge
18:00-19:00	Drinks reception	

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About

The Leeds Institute for Fluid Dynamics (LIFD) is a cross-disciplinary research institute bringing together the expertise of over 200 members of staff, postdoctoral researchers and PhD students with teaching and research interests in fluid dynamics.

The institute was established in 2018, and builds on a 50 year interdisciplinary track record of research in fluids. We provide a hub to facilitate world-leading research and education in fluid dynamics and to bring interdisciplinary perspectives to complex flow challenges.

Our planned activities include (though are not limited to):

Annual lecture, seminar programme

Research visits, visiting professors, strategic international partnerships

Strategic appointments to strengthen collaborative activity

MSc programme, summer school, technical short courses

Alumni association

Coordination in experimental facilities

Outreach including diversity and fluids demo models

Industry membership – consultancy, training, expertise

Secondments to end-users

High Performance Computing in Fluids

Establishment of user groups for use of commercial and open-source software in fluids.

Find out how to work with us:

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Executive Committee Staff

Prof. Steve Tobias (LIFD Director, School of Mathematics)
Prof. Cath Noakes (LIFD Deputy Director, School of Civil Engineering)
Prof. Chris Davies (LIFD Deputy Director, School of Earth and Environment)
Dr. Claire Savy (LIFD Centre Manager, School of Computing)

Conference Speakers

Steven Boeing– research fellow at the University of Leeds, PhD from Delft University of Technology.

“Essentially Lagrangian simulation of turbulence, mixing and phase transitions with the Ellipsoidal Parcel-in-Cell model.”

Abstract: Lagrangian flow trajectories are a ubiquitous tool in atmospheric and oceanographic science. These trajectories are used to analyse dynamical processes as well as e.g. chemical dispersion. However, a Lagrangian perspective can also be useful for solving the equations of motion. I will discuss collaborative work to build a geophysical fluid dynamics model based entirely around Lagrangian parcels, going beyond the semi-Lagrangian approach (which uses a Lagrangian framework for advection, but is still largely grid-based).

The parcels in this Ellipsoidal Parcel-In-Cell (EPIC) model represent both the thermodynamic and the dynamical prognostic properties of the flow. An efficient grid-based solver calculates parcel advection velocities, but diffusive regridding operations are avoided. The Lagrangian approach of EPIC has a number of advantages that are particularly relevant to moist convection and chemistry: thermodynamic/tracer properties and their correlations are naturally conserved, and the amount of mixing between parcels is explicitly controlled. I will present results demonstrating the performance of EPIC relative to grid-based codes and talk about ongoing work to address challenges in applying this method as a comprehensive alternative to Large Eddy Simulation or Direct Numerical Simulation.

* Work with David Dritschel (University of St Andrews), Matthias Frey (University of St Andrews), Alan

Alexander Edwards– PhD student at the CDT of Fluid Dynamics at the University of Leeds

Transient Models for Assessing Airborne Infection Risk in Naturally Ventilated Hospital Wards.

Abstract: Having the ability to understand and model airflow in indoor environments is a useful tool for many scenarios, especially when considering the transmission of airborne infections. Quantification of the parameters that influence airborne infection risk is particularly important in many traditional UK hospitals, which often rely heavily on natural ventilation as their main source of airflow in patient wards, and where the consequence of infections amongst vulnerable individuals can be very significant. Despite the transient occupancy and inter-connected nature of hospital wards, the majority of airborne risk models assume steady-state conditions and well-mixed air in a single zone. We propose a multi-zone model, using an adapted version of the Wells-Riley model coupled with a CONTAM airflow network model; we incorporate the effects of transient external weather conditions and ventilation patterns to estimate transient airborne virus concentration. Our results suggest that a steady-state approach could lead to an overestimation of infection risk or underestimation of quanta emission, especially when the infectious person is only present for a short period. We further demonstrate that the use of natural ventilation with varying weather conditions, when explored over longer periods, can cause irregularities in the inter-zonal flows rates of the connected zones and thus, lead to occasional unexpected peaks in the concentration of airborne pathogen in particular rooms, increasing the risk of infection. Our model emphasises the need for consideration of transient factors and external conditions when assessing the risk of transmission of airborne infection in indoor environments.

Julie Frank– PhD student at the CDT of Fluid Dynamics at the University of Leeds.

“COVID-19 Pathogen Transport in naturally ventilated bus.

Abstract: A dominant mode of transmission for COVID-19 is via airborne virus-carrying aerosols. As national lockdowns are lifted, and people begin to travel again, an assessment of the risk associated with different forms of public transportation is required. This work assesses the risk of transmission on naturally ventilated buses where different strategies to reduce the concentration of aerosols on the bus by opening windows and doors are considered. Numerical simulations are conducted at 3 different bus velocities (1, 5 and 15 m/s). The turbulent air flow entering the bus is modelled by using a steady RANS approach, and a transport equation is used to calculate the aerosol concentrations at different locations in the bus. Subsequently, simulation results are compared to the transmission risk on motorcycle taxis.

Dr Paul Linden- Director of Research and the GI Taylor Professor Emeritus of Fluid Mechanics in the Department of Applied Mathematics and Theoretical Physics, and Professorial Fellow Emeritus of Downing College, University of Cambridge.

The fluid mechanics of STAMP collecting: what SID tells us

Abstract: The stratified inclined duct (SID) is a relatively new experimental paradigm that produces a sustained shear flow between two counterflowing layers of fluid supplied by reservoirs at each end of the duct containing fluids of different density. The duct can be tilted at a small angle θ to the horizontal and, for a given fluid, the flow is determined by two nondimensional parameters θ and the

Reynolds number. We have observed four different flow regimes in SID: Laminar when the interface between the layers remains undisturbed, Holmboe characterised by sharp cusped waves on the interface, Intermittent when the flow has bursts of turbulence followed by relatively calm periods and Turbulent when the turbulence occurs throughout the duct and is sustained in time. The laminar regime occurs at low Re and θ, and transitions to the other regimes occur successively as Re and θ increase, so SID allows a systematic study of the different regimes. One of the most important questions in stratified turbulence is the efficiency with which the fluid

is mixed. When the stratification is stable, with density decreasing with height, work needs to be done against gravity to move light fluid downwards and dense fluid upwards so that irreversible mixing can occur. The 'tax' that this irreversible mixing imposes on the kinetic energy of the flow, the so-called 'mixing efficiency' is important to parameterise mixing in ocean and climate models. In this talk I will discuss the philosophy behind SID and explain why the experiment is relevant to this issue, particularly in the context of the energetics of the flow. We summarise our results on turbulent energetics and mixing statistics. We derive the kinetic and scalar energy budgets and explain the specificity and scalings of SID turbulence. We focus on the self-organisation properties of the flows, wherein more strongly turbulent flows tend to an asymptotic state characterised by a uniform gradient Richardson number of order 0.1-0.2 across the shear layer. We assess the relevance of standard mixing parameterisations models, and we compare representative values with the literature. Complementing the experiments we introduce the first accurate 3D DNS for SID. Implementing a suitable forcing method and boundary conditions allow us to maintain steady exchange flow for an arbitrarily long time at a minimal computational cost. With the newly developed numerical model, we explore the diverse transitions in SID from a numerical perspective.