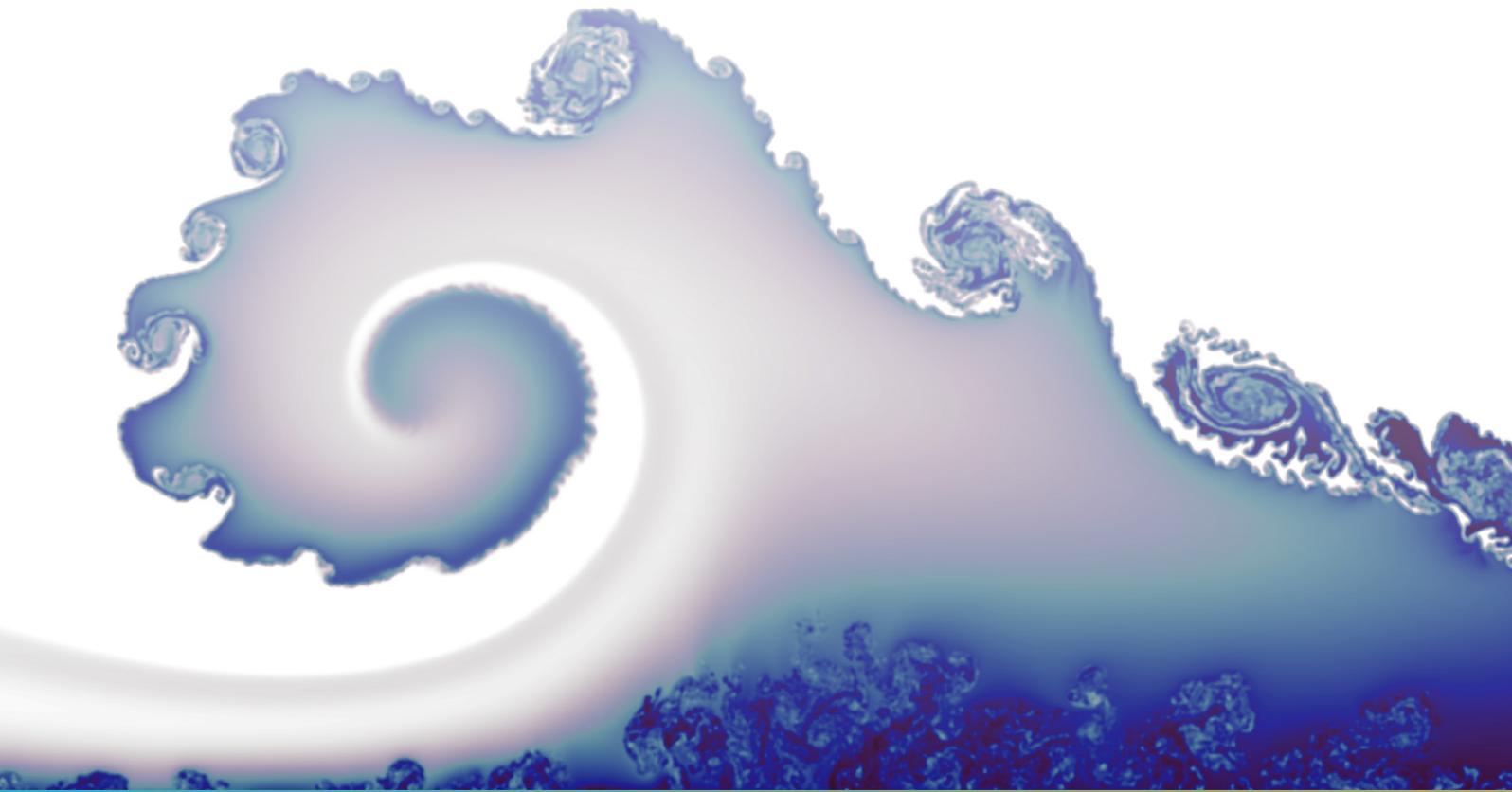


# LIFD

Leeds Institute for  
Fluid Dynamics

## LEEDS INSTITUTE FOR FLUID DYNAMICS



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**Front cover:** Density in the head of a gravity current, from a simulation with the Moist Parcel-in-Cell model  
 Image: S Boeing, School of Earth and Environment, collaboration between the Universities of Leeds and St Andrews

**2D simulation showing high concentration of Silicon formed in the solid as a faceted crystal forms out of an Aluminium-Silicon melt**

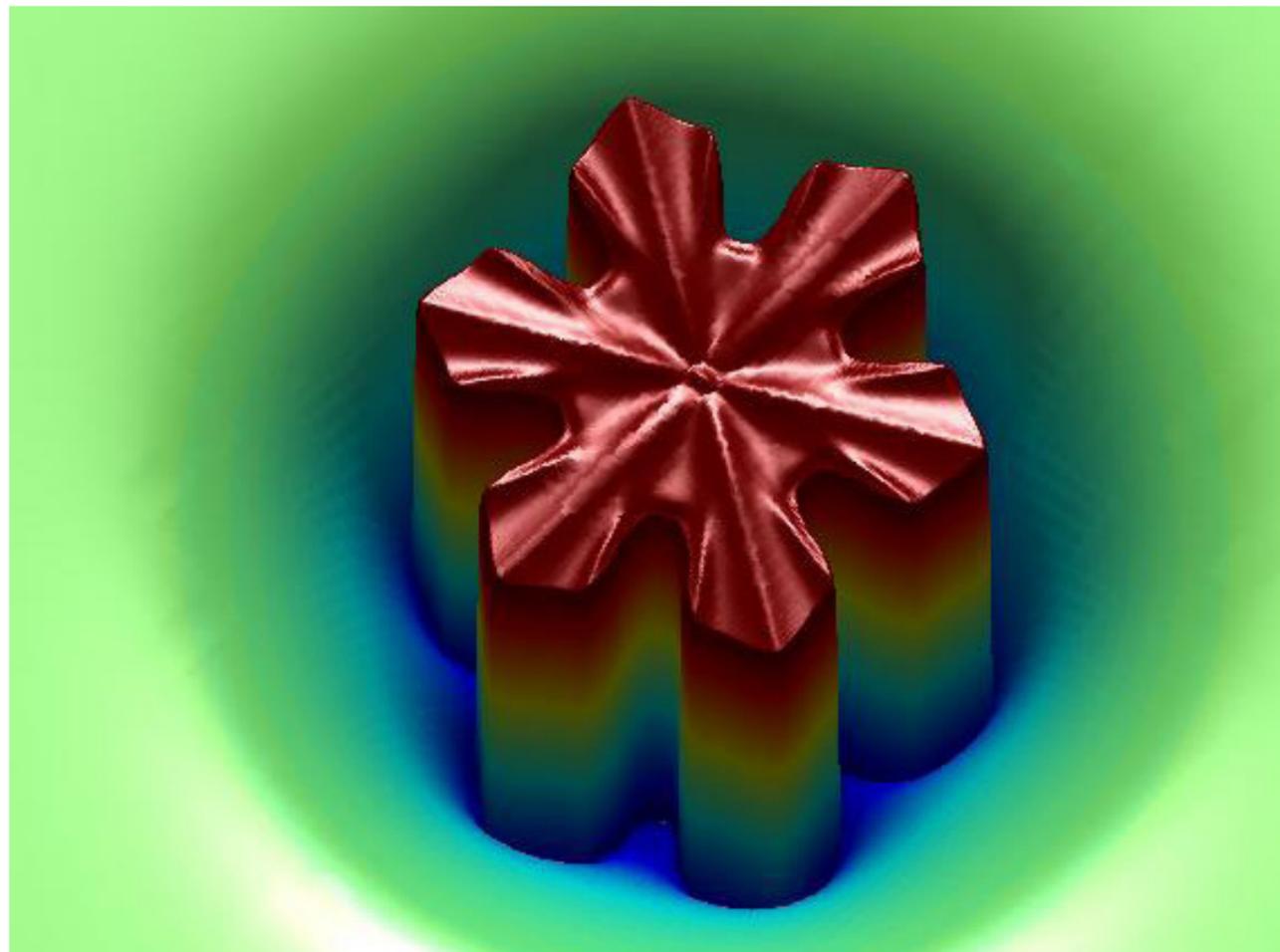


Image: P. Bollada, School of Computing

## Fluids at Leeds

**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 objectives focus on four key areas:

*International standing:* To be a world leading centre for Fluid Dynamics, and to continue to build the UK reputation for international excellence in fluid dynamics;

*Collaborative research capabilities:* To enable excellence through collaboration, facilities and support to researchers;

*Strategic partnerships:* To build and maintain partnerships worldwide with end-users, academia, funders and alumni;

*Excellence in training:* To support cross-disciplinary postgraduate level training through MSc, PhD and short courses.

Researchers from  
12 schools and 4  
faculties

Over £77M in current  
grants

Over 50% of papers  
from international  
collaborations

Collaborations with  
researchers in over 85  
countries

2800 papers in the  
past 5 years; 50% in  
top 10% journals

Impact with leading  
Industry partners

## Our Research

Fluid Dynamics lies at the heart of numerous challenges in industry and society. Our research focuses on fundamental physics and underpinning methodologies for fluids as well as applications to societally significant problems in:

- Energy and Transport
- Environmental Flows
- Geophysical and Astrophysical Flows
- Biomedical Flows
- Industrial Processes

Delivering new innovation to drive productivity, health and a sustainable environment across all these challenge areas requires a deep understanding of Fluid Dynamics principles and the right collaborations and partnerships to deliver world-leading research and enable impact.

### CFD simulation of around a cube array, exploring ventilation flows in city environments

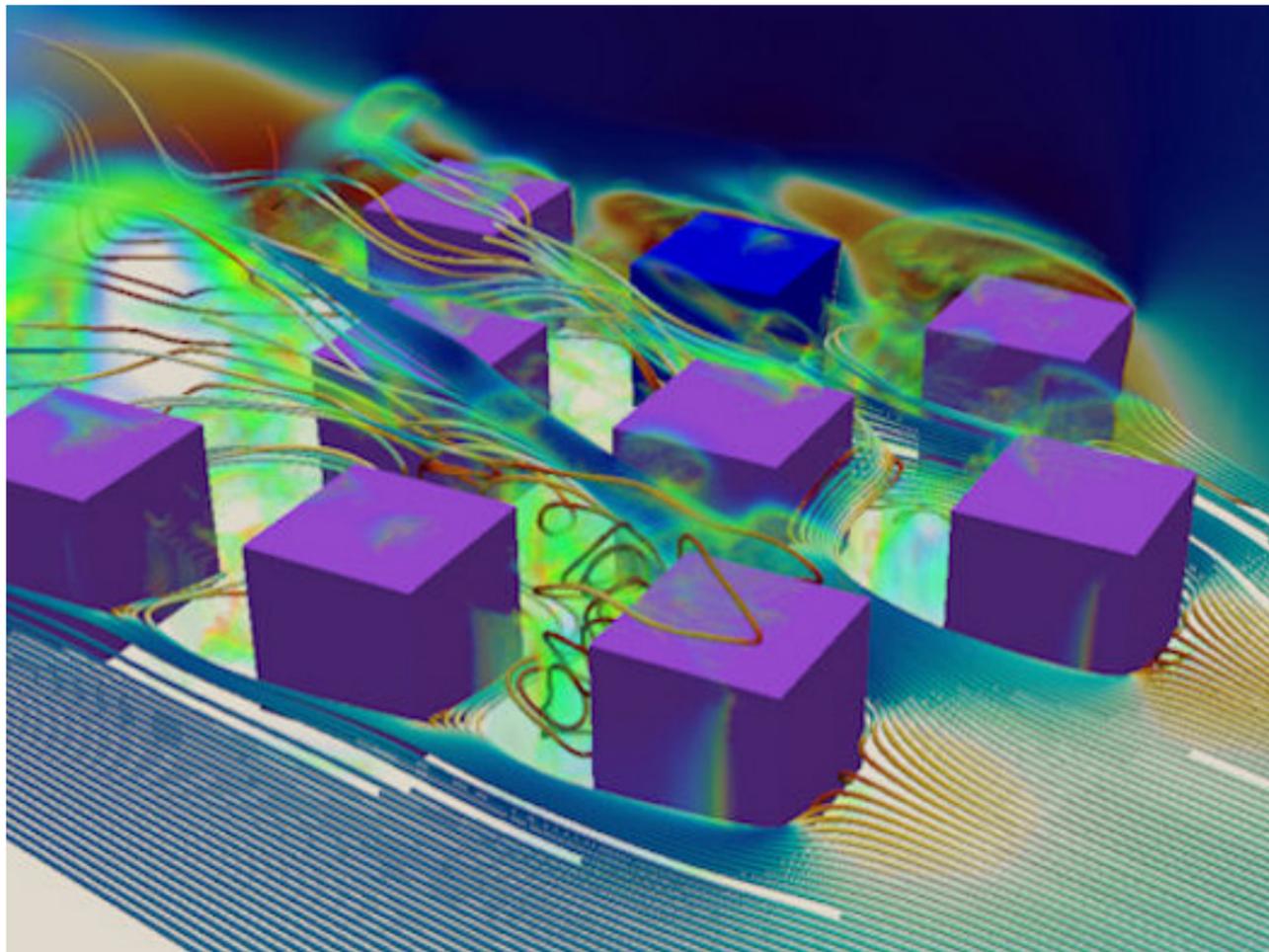


Image: M.F.King, School of Civil Engineering

## Energy and Transport

Our research ranges from reacting flows in internal combustion engines, through to mixing problems in nuclear waste, fluid-structure interaction in wind energy, and multiphase flows in oil and gas fields. Academic expertise includes: engine combustion and tribology; aerodynamics and shape optimisation; heat transfer; and turbidity currents.

Our external partners include nuclear industries with interests in suspensions, multiphase flows and mixing; fuel industries on combustion, lubrication and production; and the aerospace industry on heat transfer problems.

## Environmental Flows

Our research explores multiple environmental challenges involving transient and multiphase flows in complex geometries. Applications range from large scale river and estuary flows and urban air quality, to local flooding and storm hazards, water infrastructure and the indoor environment.

Specific expertise includes: water waves, including their impact on maritime structures; flood risk modelling; sediment transport; meteorology and climate dynamics; air pollution dispersion; geotechnical flows; wastewater treatment; indoor air flows. We work with partners ranging from civil engineering companies with interests in hydraulic infrastructure, urban wind and ventilation flows and heat transfer to the Met Office on large scale atmospheric flow.

### Analysing seafloor gravity currents

Flume PIV and seafloor data show internal wave structures, concentration and velocity profiles and mixing. Findings influence prediction of duration, erosion and deposition, supporting risk analysis for marine infrastructure.

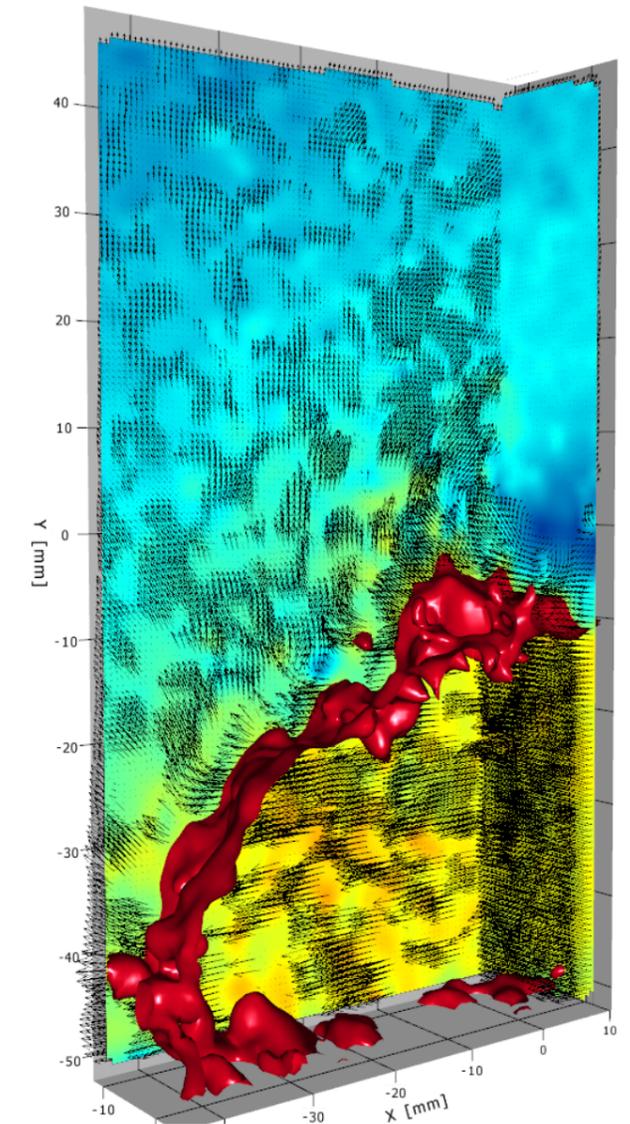


Image: G Keevil, J Peakall, School of Earth and Environment, C Marshall, CDT in Fluid Dynamics

## Geophysical and Astrophysical Flows

We have an exceptional track record in fundamental processes related to geophysical and astrophysical flows. Expertise includes: convection in multi-phase flow; atmospheric and oceanic turbulence; non-Newtonian flow and fluid-structure interaction in dynamics of marine ice sheets; the fluid mechanics of the deep Earth; and solar, stellar and planetary processes.

Techniques range from fundamental analysis and statistical methods, to large scale field observation and highly parallel computational simulation.

### Statistical behaviour of turbulence

We are developing statistical models to investigate the interaction of turbulent fluid flows, rotation and magnetic fields with applications from the jet-stream on Earth and zonal jets on Jupiter to generation of zonal flows in plasma confinement devices for fusion.

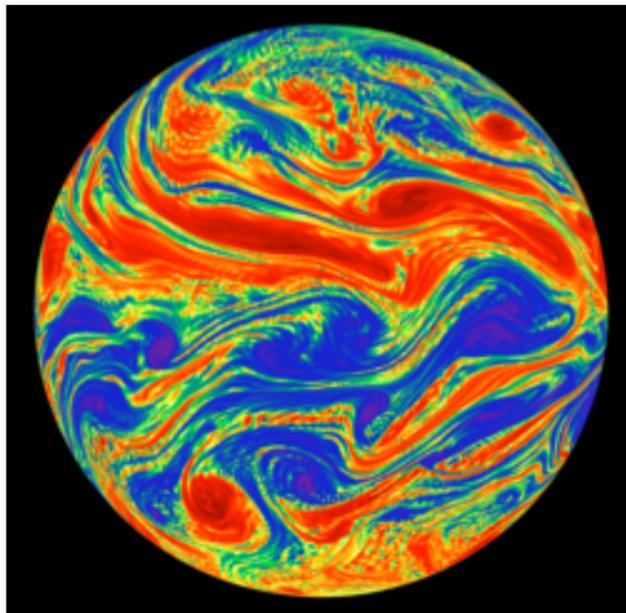


Image: S Tobias, School of Mathematics

### Improving Storm Forecasting in the Tropics

Through collaboration with the Met Office and partners in Africa and India, we are testing and improving predictive models for weather and climate. We have shown how changes in the wind dynamics over West Africa impact on extreme rainfall events



Image: D Parker, School of Earth and Environment

## Biomedical Flows

We have major strengths in fluid dynamics relating to cardiovascular disease including advanced facilities for 4D MRI imaging and coupling imaging with CFD modelling to analyse disease mechanisms and predict outcomes of interventions.

Our biomedical flow expertise also includes microfluidic diagnostics for biological flows; drug delivery; microbial dispersion and infection control; and modelling of flows in tissues and tumours. We work closely with pharmaceutical companies and medical imaging industries as well as Public Health England and the NHS to ensure that research outcomes have a real benefit for public health.

### Analysing ventricular flows

Using 4D flow cardiac magnetic resonance (CMR) we have established the changes in intraventricular kinetic energy flow in patients with impaired and preserved heart function. We are coupling MRI with CFD modelling to develop predictive tools to optimise vascular treatments.

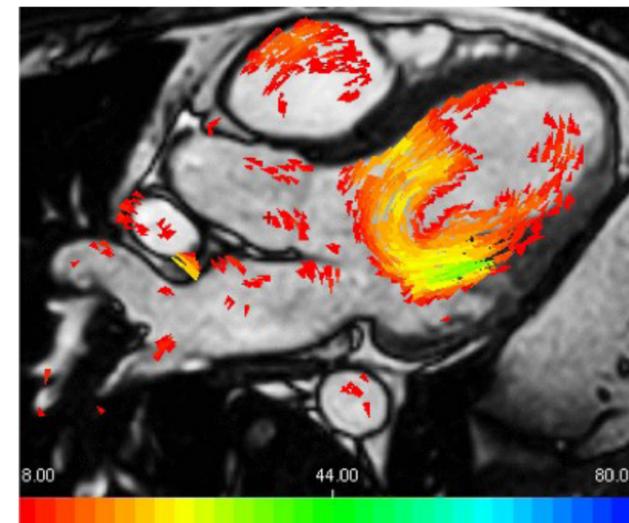


Image: E. Dall'Armellina, Leeds Institute of Cardiovascular and Metabolic Medicine

### Innovating inkjet technology

We have developed Finite Element based mathematical models that simulate fluid jetting behaviour as a function of fluid and surfactant properties to capture inkjet break-up and drop formation. The simulation enables optimisation to be carried out in-silico and has application in a wide range of biological and biochemical processes.

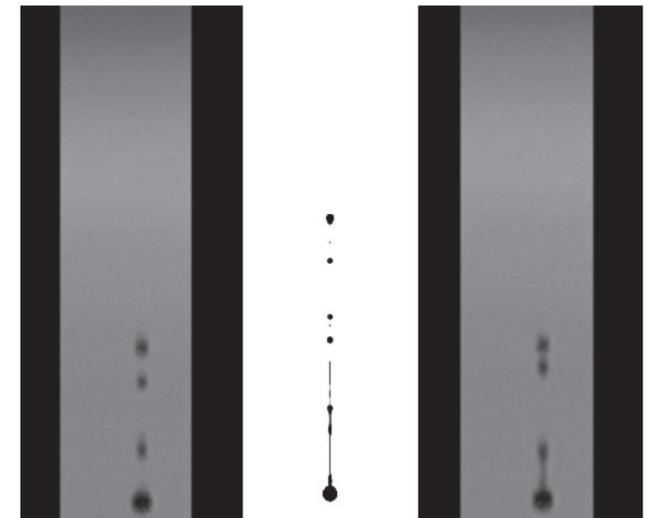


Image: E. Antonopoulou, CDT in Fluid Dynamics

## Industrial Processes

We bring together understanding of fundamental flow regimes, fluid properties and simulation approaches to tackle challenges in multiple industry sectors. Expertise at Leeds includes: wetting, coating and drying; printing and jetting of complex fluids; formation and transport of sludge and emulsions; cooling and heat transfer; corrosion; thin-film flows; and filtration.

We work closely with industrial partners across a wide range of applications including printing, additive and subtractive manufacturing, novel filtration, electronic displays, magnetic media, instrumentation and power generation.

### Optimising flows

Coupling CFD models with optimisation methods provides a new approach to improving engineering design. Applications range from coolant flows in drilling to building ventilation and vehicle dynamics, including application to the Yorkshire Ambulance Service

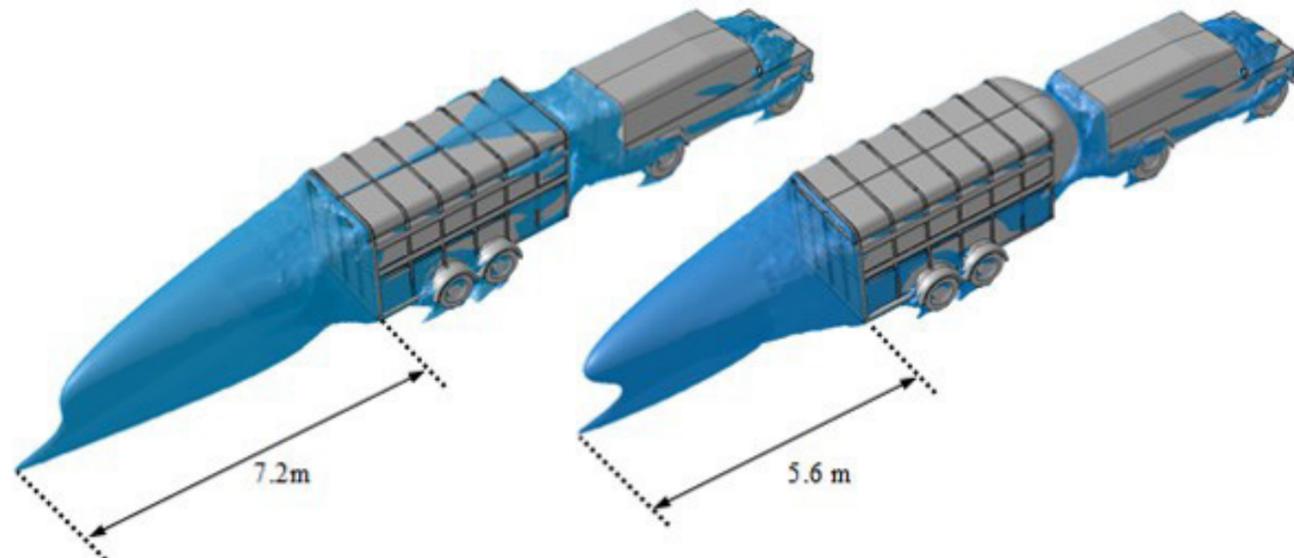


Image: H. Thompson, C. Gilkeson, School of Mechanical Engineering

## Underpinning Methods

Our substantial research into novel analytical, experimental and numerical methodologies contributes to fundamental knowledge and new techniques for fluid analysis, as well as translating this expertise into application areas. Our strengths include nonlinear dynamics; imaging techniques; and the development of novel CFD tools and numerical algorithms. We develop and modify algorithms for modern computer architectures including multi-core accelerators, GPU and large scale parallel simulation. We have partnerships with software providers and organisations with interests in developing new algorithms and solution techniques to support software for academic and industry users.

## Work with us

LIFD provides an exciting, interdisciplinary environment for researchers. We are keen to enable scholars from around the world to work with us in Leeds as a visiting researcher, join us with a funded research fellowship or collaborate in organising a conference, meeting or summer school.



### Become a Visiting Researcher

Our LIFD Fellows scheme aims to attract distinguished scholars from around the world to work with researchers at Leeds. LIFD Fellows are normally invited to spend 1-3 months in Leeds and are supported with up to £3000 to assist with expenses. We invite applications for LIFD Junior Fellows and LIFD Senior Fellows twice a year.

We also welcome visiting researchers at all career stages, including PhD students, who are hosted by the academic departments involved with LIFD.

### Academic Fellowships in LIFD

A funded fellowship is a prestigious award offering flexible and independent research funding to explore large scale and challenging research ideas. We are keen to support scholars from around the world who are interested in applying for an externally funded fellowship to join the University of Leeds.

Fellowship opportunities are available for all career stages, from recent PhD graduates through to senior Professors. Eligibility varies by scheme, career stage, discipline and country; however there are a wide range of schemes from UKRI and EU funders that align to Fluid Dynamics disciplines. We offer support to applicants to prepare exciting and competitive fellowship proposals, as well as mentoring and guidance to develop your career in Leeds if your proposal is successful.

## Conferences, Meetings and Summer Schools

Within LIFD we offer a wide programme of seminars, lectures, conferences and training events aimed at both academic and industry audiences.

Our flagship **LIFD Research Programme** is a two week workshop that will run every two years to gather leading international experts in a specific area of fluid dynamics. Through a series of lectures and workshops this meeting aims to advance the science and understanding of specific fluid challenges and build new collaborative partnerships.

The **LIFD summer school** will run annually, focusing on a different area of fluid dynamics each year. Primarily aimed at graduate students, this concentrated one week course will develop both core discipline skills and share the current research advances in the discipline.

We are keen to partner with the international fluids community to organise events that actively support researchers across the diversity of fluids research. LIFD will support the organisation and promotional aspects of these meetings, enabling academic collaborations to focus on the scientific content of the meeting. Please talk to us if you are interested in collaborating with LIFD to organise a conference or meeting, or chairing one of our Research Programmes or summer schools.

### Turbulent flow simulation over a shark skin

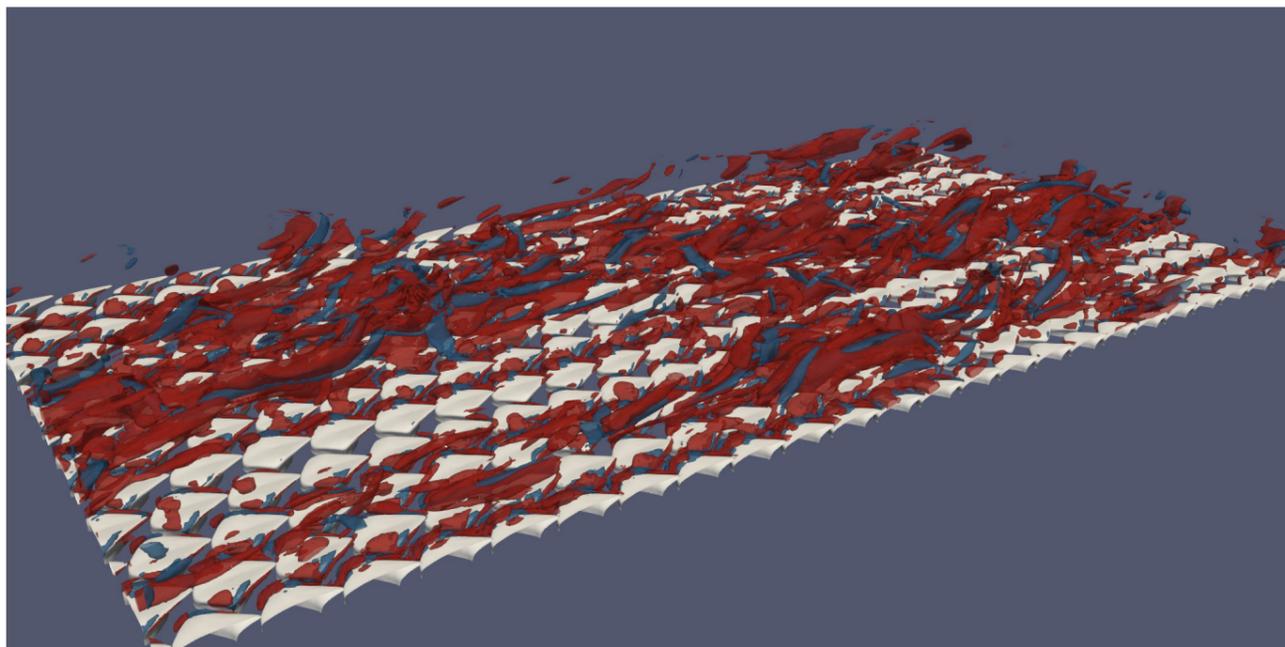


Image: C Lloyd, CDT in Fluid Dynamics

## Industry and End-User Partnerships

Partnerships with industry and end-users are critical across our research portfolio, enabling definition of relevant research projects and facilitating impact into guidance, policy and practice. We use industry facing study groups, workshops and sandpit events to explore challenges, and we have a range of mechanisms for collaborative working with external partners, offering different timescales, costs and complexity.

Student Routes	Grant funded	Direct support
<p><b>Undergrad/MSc projects</b></p> <p>Short term (3-6 months), low risk, low cost. Ideal way of building a relationship and exploring an idea.</p>	<p><b>Knowledge Transfer Partnerships</b></p> <p>Cost share scheme for industry driven R&amp;D projects, typically 2-3 years with a dedicated research associate.</p>	<p><b>Consultancy</b></p> <p>Short term with retention of IP, but relatively high cost. Good for short focused projects.</p>
<p><b>Co-funded PhDs</b></p> <p>Ideal for underpinning research to support new ideas. Cost share with research council via CDT or CASE schemes. Typically 3-4 years.</p>	<p><b>Innovate funding</b></p> <p>Industry led grant schemes focusing on strategic R&amp;D and in partnership with academia.</p>	<p><b>Direct funded research</b></p> <p>Lower cost than consultancy, developed in partnership with academic. Usually allows retention of IP.</p>
<p><b>Fully sponsored PhDs</b></p> <p>Similar to co-funded, but enables stronger partner steer and retention of IP.</p>	<p><b>Research grant partner</b></p> <p>Academic led projects, with industry partner in-kind or small value. Low risk, but over longer timescale. Good for building relationships.</p>	<p><b>Strategic partnership</b></p> <p>Long term approach, usually where there are multiple connections or projects. Supported through a partnership agreement</p>

## Study with Us

### EPSRC Centre for Doctoral Training in Fluid Dynamics

Our EPSRC Centre for Doctoral Training (CDT) in Fluid Dynamics tackles fundamental and applied problems providing students from a wide range of academic backgrounds with the opportunity to undertake cutting-edge, multidisciplinary research.

Students undertake an integrated 4 year MSc and PhD combining theoretical, experimental and numerical training with a strong programme of professional development and a research project with cross-disciplinary supervision. The programme was launched in 2014 and will support at least 10 students per year until 2023.

### International PhD Opportunities

We welcome enquiries from international PhD candidates who are interested in carrying out their doctoral studies in Leeds. We offer a vibrant research environment which attracts students from over 170 countries.

Many of our students can align their studies with the Centre for Doctoral Training, enabling access to taught courses and professional development alongside their PhD. Students are supported through the Leeds Doctoral College which offers a wide range of training, personal development and peer support.

Opportunities are available across Engineering, Mathematics, Environmental Sciences, Physics & Biomedical Sciences.

### MSc programmes

Our 1 year MSc programmes offer the chance to build in-depth knowledge in a discipline area, and all include a substantial research dissertation component. We have several MSc programmes at Leeds which develop aspects of fluid dynamics including:

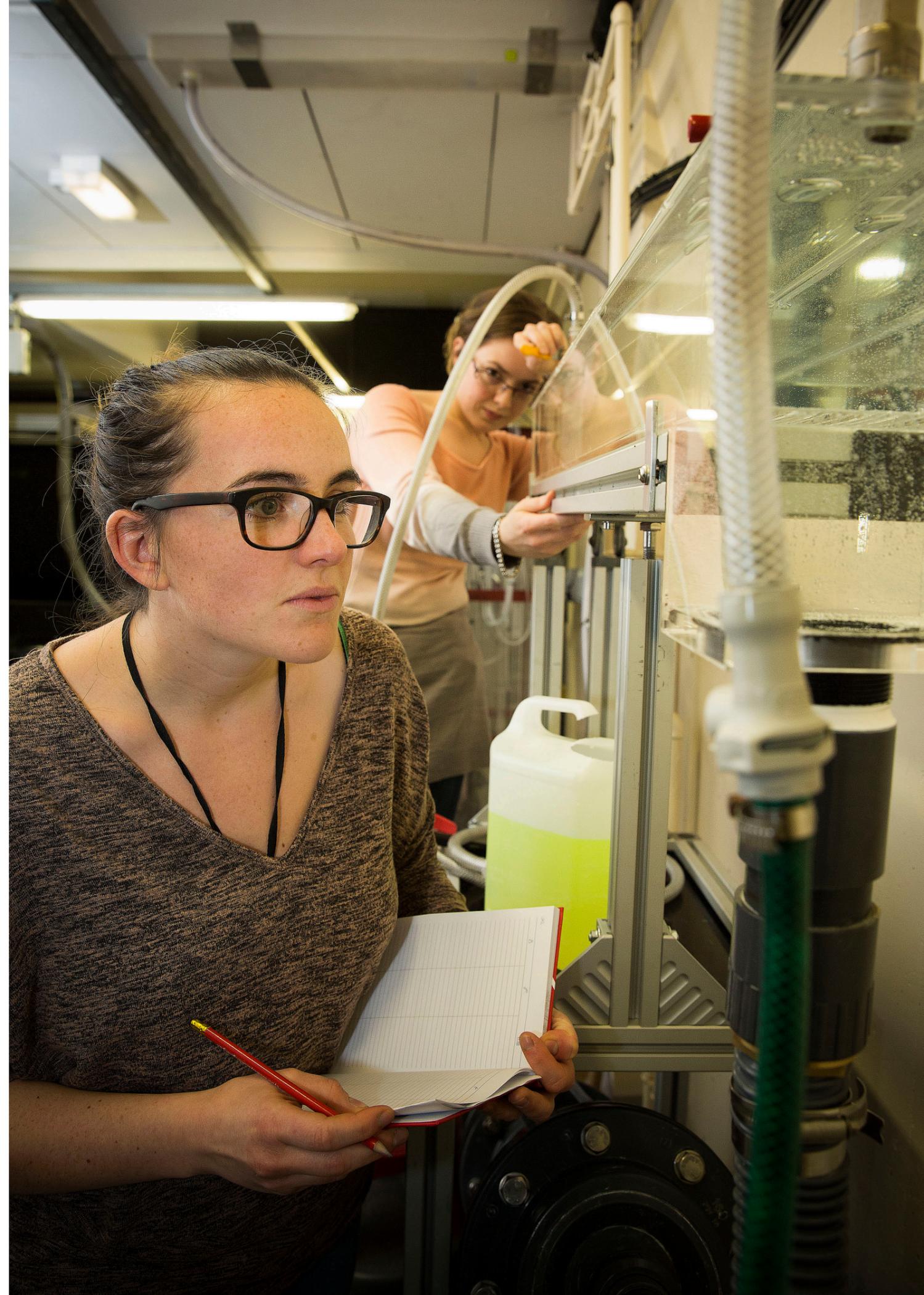
- Advanced Chemical Engineering
- Advanced Mechanical Engineering
- Aerospace Engineering
- Chemical Process Engineering
- Climate and Atmospheric Science
- Energy and Environment
- Exploration Geophysics
- Mathematics
- Petroleum Production Engineering
- River Basin Dynamics and Management with Geographical Information Systems

### Studying in Leeds

The University of Leeds is one of the largest universities in Britain with over 38,000 students and more than 7,000 staff, including over 2,000 academic and academic-related staff.

We offer excellent facilities to support your studies including state-of-the art laboratories, high performance computing and a wide range of library and support services such as language support.

The campus is just a 10 minute walk from Leeds city centre which offers a wide range of social, retail, sporting and cultural activities. The city is within easy reach of the beautiful Yorkshire countryside enabling access to outdoor activities, the coast, market towns and the historic city of York.



## Public Engagement and Outreach



Inspiring the next generation is a key mission for LIFD. Fluid dynamics underpins almost everything in our lives, yet is often a hidden discipline in our school curriculum. Our researchers work closely with end-user partners to inspire curiosity and show how fluid dynamics affects the world around us. We are particularly interested in engaging school age children through interactive hands-on activities.

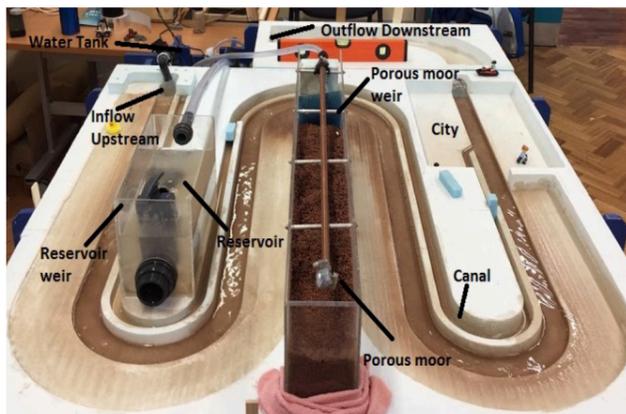


Image: O Bokhove, School of Mathematics

### Wetropolis

A novel outreach demonstration to visualise river flooding return periods. The model simulates a day every 10s and incorporates porous groundwater moorland draining into a river. Galton boards randomly determine rainfall amount and location, enabling visualisation of stochastic processes.

## Contact Us

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Professor Catherine Noakes, Deputy Director of LIFD  
**C.J.Noakes@leeds.ac.uk**

For all general enquiries please contact the LIFD Centre Manager Dr Claire Savy  
**fluids-institute@leeds.ac.uk**  
 Tel: +44 (0) 113 343 5449

If you are interested in studying with us please contact  
**fluid-dynamics@leeds.ac.uk**

For further information on postgraduate study at the University of Leeds please visit  
<http://www.leeds.ac.uk/>

### Pressure distribution for an elastic beam attached to a fixed square block

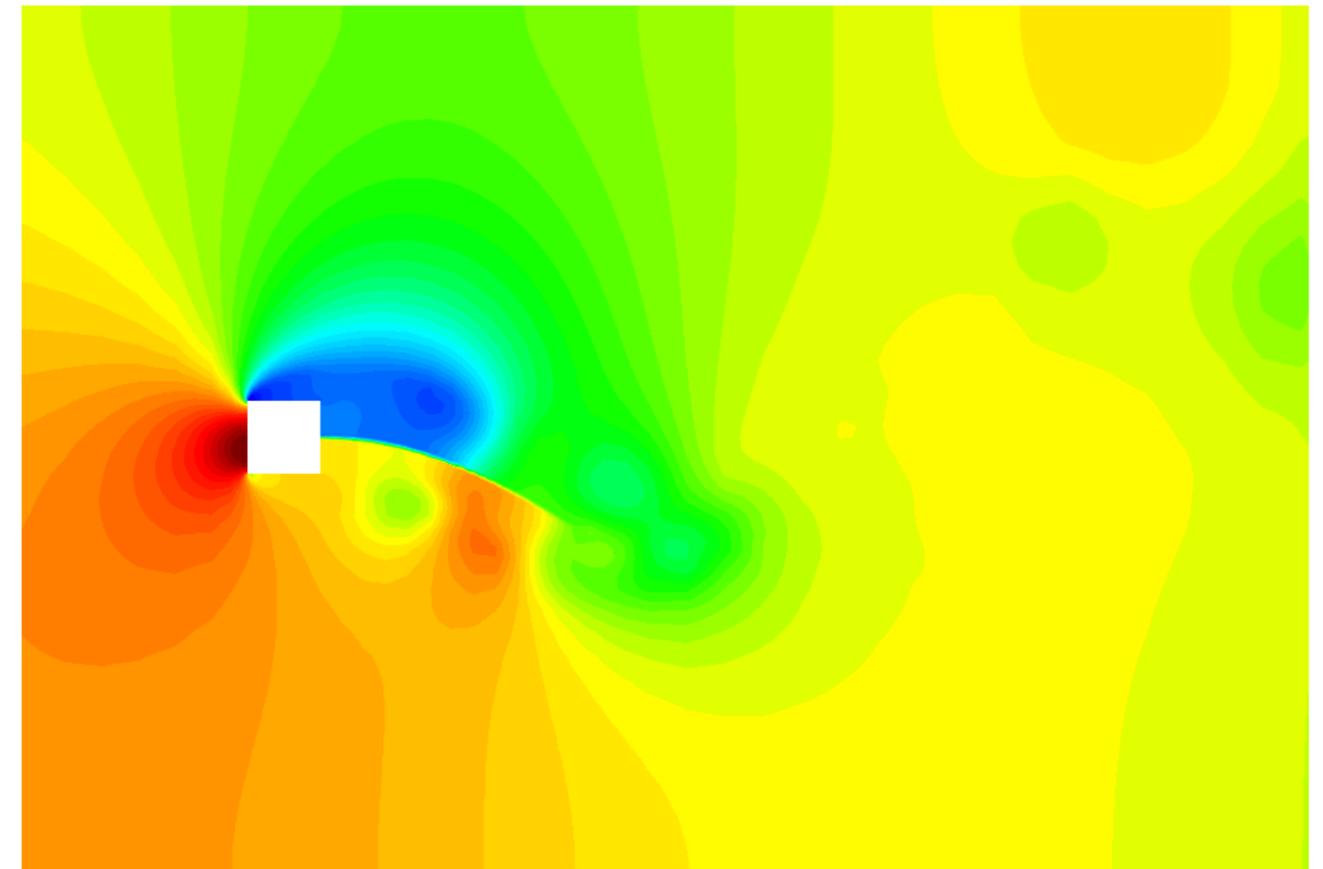


Image: Y Wang, School of Computing

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