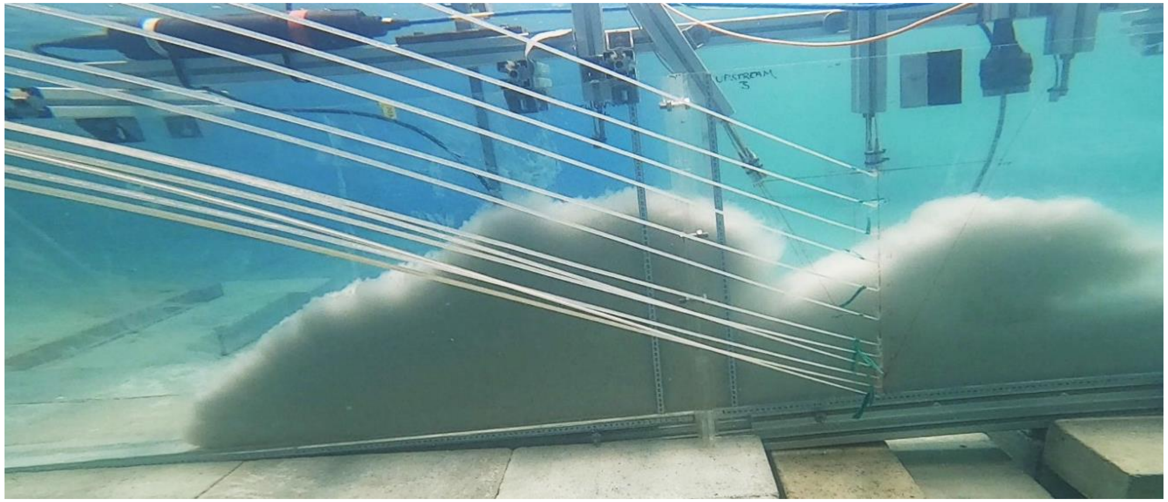
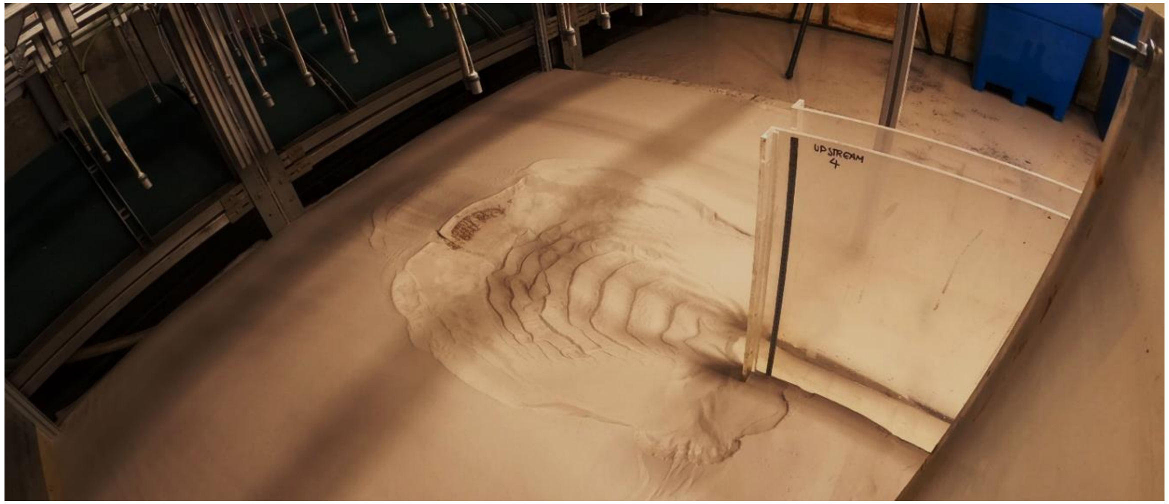
# *Particulate Gravity Currents 24*





Cover images by Dr Sojiro Fukuda and Dr Marijke de Vet, Total Environment Simulator, University of Hull

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University of Hull Fluid Dynamics Group

# Table of Contents

*This document has been amended subsequent to the completion of the conference in accordance with the events that took place.*

# 1 Schedule

The schedule for keynotes, speakers and events. Times shown are at the start of a 20-minute window. The Talk ID links to talk title and abstract.

| Time | Monday 9th September | | Tuesday 10th September | | Wednesday 11th September | |
|---|---|---|---|---|---|---|
| 09:00 | Breakfast & Registration | | Keynote 3 - | Gary Parker & Toshiki Iwasaki, Talk ID 5.3 | Keynote 5 - | David Mohrig Talk ID 5.5 |
| 09:20 | | | | | | |
| 09:40 | | | | | | |
| 10:00 | Keynote 1 - | Andrew Hogg Talk ID 5.1 | Patrick Sharrocks | Talk ID 6.9 | Rebecca Williams | Talk ID 6.21 |
| 10:20 | | | Steve Simmons | Talk ID 6.10 | Jordan Chenery | Talk ID 6.22 |
| 10:40 | | | Daniela Vendettuoli | Talk ID 6.11 | Coffee | Lab Tours 5 |
| 11:00 | Alan Cuthbertson | Talk ID 6.1 | Coffee | | | |
| 11:20 | Gareth Keevil | Talk ID 6.2 | Chris Stevenson | Talk ID 6.12 | Thomas Johnston | Talk ID 6.23 |
| 11:40 | Sojiro Fukuda | Talk ID 6.3 | Carolina Holz Boffo | Talk ID 6.13 | Chris Johnson | Talk ID 6.24 |
| 12:00 | Kyle Straub | Talk ID 6.4 | Rafael Manica | Talk ID 6.14 | Magda Carr | Talk ID 6.25 |
| 12:20 | Lunch | | Lunch | | Lunch | |
| 12:40 | | | | | | |
| 13:00 | | | | | | |
| 13:20 | Keynote 2 - | Claudia Adduce Talk ID 5.2 | Keynote 4 - | Anne Mangeney Talk ID 5.4 | Keynote 6 - | Eckart Meiburg Talk ID 5.6 |
| 13:40 | | | | | | |
| 14:00 | | | | | | |
| 14:20 | Peng Hu | Talk ID 6.5 | Pella Adema | Talk ID 6.15 | Herbert Huppert | Talk ID 6.26 |
| 14:40 | Hajime Naruse | Talk ID 6.6 | Débora Koller | Talk ID 6.16 | Amirul Khan | Talk ID 6.27 |
| 15:00 | Edward Skevington | Talk ID 6.7 | Mia Hughes | Talk ID 6.17 | Charlie Lloyd | Talk ID 6.28 |
| 15:20 | Coffee & Posters | Lab Tours 1 | Coffee & Posters | Lab Tours 3 | Coffee | Lab Tours 6 |
| 15:40 | | | | | | |
| 16:00 | Marius Ungarish | Talk ID 6.8 | Yan Li | Talk ID 6.18 | Ben Kneller | Talk ID 6.29 |
| 16:20 | | | Leo Corredor Garcia | Talk ID 6.19 | Bruno Alvarez Scapin | Talk ID 6.30 |
| 16:40 | Lab Tours 2 | | Natalia Lipiejko | Talk ID 6.20 | | |
| 17:00 | | | Lab Tours 4 | | | |
| 18:45 | | | Conference Dinner, The Deep | | | |

# 2 Key Information

- The conference is to be held at the Aura Innovation Centre, starting Monday 9th September with registration 9am-10am. Please arrive in good time to be registered. See section 11 for a map of the conference venue, and section 4 for transport information.
- The conference dinner will be at The Deep on the evening of Tuesday 10th September at 7pm. See section 11 for a map.
- See section 3 for instructions to presenters, including details on bringing your presentation/poster.
- At the venue WiFi can be accessed via eduroam. If you do not have access to eduroam you can follow the instructions on the University website.

# 3 Instructions for Presentations

## 3.1 Oral Presentations

Our preference is that presentations are performed from the computer we provide. To achieve this please prepare your presentation in PowerPoint (ppt/pptx) or PDF format, and name it in the format "Talk ID - Surname".

You may upload your presentation from a memory card, please do so no later than 15mins before the first presentation of the day (09:45 on Monday, 08:45 on Tuesday/Wednesday, for the latter days you may also upload your presentation on a previous day). Remember that there will be many people attempting to upload presentations to please leave plenty of time. If you have your presentation ready in advance then please email to eei@hull.ac.uk no later than the Thursday 5th September.

Presentations can also be performed from a laptop the presenter brings; *this is done at the presenter's own risk*. The connection to the screen can be made via an HDMI cable.

The screen aspect ratio is 16:9. The main screen is large and goes all the way to the floor, and repeater screens will be positioned for people towards the back of the room to see the full slides.

### 3.1.1 Keynote Presentations

The keynote presentations are given an hour slot, we recommend 45 minutes for speaking, 14 minutes for questions, and 1 minute for changeover. You may discuss adjusting the length of talk and questions with your chair, but the keynote presentation must end after the hour. The chair will indicate these times, or the agreed times, as appropriate.

### 3.1.1 Standard Presentations

Each talk is given a 20 minute slot, we recommend 16 minutes for speaking, with 3 minutes for questions, and 1 minute for changeover. The session chair will indicate to you when you should be moving on to questions (but you may continue if you wish). When it is time for the next presenter to start the chair will end the presentation/questions.

## 3.2 Posters

Posters must be able to fit on a poster board of size 150x150cm; at most A0. Please bring your poster with you, if this is not possible please contact eei@hull.ac.uk for advice. Posters will be available throughout the conference, with dedicated sessions in the afternoon of days 1 and 2. Signs will be attached to each board, for presenters to complete when they are available to discuss their work.

# 4 Transportation

## 4.1 Buses

Cheapest travel is by bus, where singles are £2 and card is accepted. For those travelling from the City Centre to the AIC, the most convenient bus is:

| | |
|---|---|
| From: | Paragon Interchange (probably Bay 10) |
| To: | Boothferry Road |
| Number: | 350 |
| Departs: | 7:55 |

Buses from Paragon Interchange leave promptly at their scheduled time, in other places they are less reliable.
To find other buses, google maps will tell you the scheduled times, for live updates on bus locations you can use the apps for the two bus companies.

- Stagecoach Buses: iOS Android
- East Yorkshire Buses: iOS Android

## 4.2 Taxis

***Uber is not available in Hull***, you will need to make use of local taxi companies instead. Some of these have apps similar to the Uber app, see below.

- Drive +44 (0)1482 575757 App: iOS Android
- Hull Cars +44 (0)1482 828282 App: iOS Android

## 4.3 Parking

There is parking immediately outside the conference venue if required, to find the venue use HU13 0GD in your satnav, and for the dinner HU9 1TU. When you arrive at Aura please inform us that you have used a parking space and have your vehicle details ready so we can add you to the system.

## 4.3 Bicycle

There is a secure bike shed and showers at the conference venue, you can ask for access to these at registration.

## 4.4 Maps

Maps are appended at the back of the program.

# 5 Keynote Abstracts

## 5.1 Huaycos and Lahars: models of large-scale, erosive flows

Presenter: *Andrew J. Hogg, School of Mathematics, University of Bristol, UK*

Huaycos - flash floods in the Peruvian Andes - and lahars – volcanic debris flows - are potent natural hazards that threaten lives and livelihoods. They comprise sub-aerial debris-laden fluid that flows rapidly down steep slopes, bulking up considerably through erosion of the underlying bed as they progress, potentially transforming from dilute to concentrated states. Owing to their rapid onset and the significant threat that they pose to communities and infrastructures, it is important to predict their motion to assess quantitatively some of the impacts that they may cause. This paper presents a new mathematical model of the physical processes that govern the motion and a new, free-to-use implementation of a numerical algorithm to integrate them, which may be used operationally to predict the flows quantitatively. In addition, it will be shown how these advances apply to the closely related motion of large-scale, subaqueous turbidity currents.

These mass flows of sediment at environmental scales are modelled on the assumption that they are shallow (i.e. their flow depth is much smaller than streamwise extent), so that the motion is predominantly parallel to the underlying bed. The streamwise balance of momentum includes down slope acceleration, basal drag and streamwise pressure gradients, while the composition of the flow and the bed elevation are altered through particle erosion and deposition. Two key advances are required to make this system of governing equations useful for predictions: first, the identification and removal of a mathematical pathology that renders naïve implementations of this system, mathematically ill-posed, and second, the projection of the governing equations into earth-centred coordinates, which permits use with measured topography.

Examples will be presented of model predictions worldwide, including those used for hazard assessment, alongside idealized solutions that draw out the interplay of erosion, dynamical transformation and morphodynamical equilibria.

## 5.2 Entrainment in gravity currents over complex boundaries

Presenter: *Claudia Adduce, Roma Tre University, Italy*

Gravity currents are flows caused by a density difference between two fluids, which can be due to temperature and salinity gradients or sediment concentration. Gravity currents can occur in the oceans as dense currents and turbidity currents or in the atmosphere as avalanches and sand storms. These currents develop over complex boundaries and the interaction with the topography can deeply affect the dynamics of these flows, the associated mixing and modify the final proprieties of water masses.

A simple technique employed to produce gravity currents in the laboratory is the lock-release. It consists in filling a tank with two fluids at different density separated by an impermeable sliding gate. When the gate is removed the two fluids interact and produce a dense current which propagates along the bottom of the tank and entrains ambient fluid.

In this talk, the dynamics of gravity currents flowing over complex boundaries are presented. Gravity currents flowing over small and steep slopes, single triangular obstacle and an array of obstacles, are analyzed by both laboratory experiments and Large Eddy Simulations. In the laboratory, gravity currents are produced by a lock release and an image analysis technique is applied to measure instantaneous density fields. Relevant dimensionless parameters, as Reynolds and Froude numbers and depth ratios, are varied and their effect on the gravity currents dynamics and the associated entrainment are discussed for each boundary considered. The results show that the dynamics of the current is deeply affected by the presence of a complex boundary, which has an effect on both entrainment and mixing. In addition, the mixing and dilution occurring within the gravity currents become more complex when these flows develop over topographies. Then a detailed evaluation of the density structure within the mixed fluid is of central importance for the evaluation of the entrainment.

## 5.3 Numerical Modeling of Turbidity Currents: From the Continental Shelf to the Deep Sea

Presenters: *Toshiki Iwasaki, Hokkaido University, Japan*
*Gary Parker, University of Illinois Urbana-Champaign, USA*
*Contributors: Hongbo Ma, M. Cartigny, E. Viparelli, S. Balachandar, X-D Fu*

Turbidity currents play a central role in the sculpting of the ocean floor. Here we consider two mechanisms by which they do so. The first mechanism concerns continental shelf formation. We treat the shelf as a prograding clinoform, indeed, globally the largest morphodynamically-sculpted bedform worldwide. Elements of our reduced-scale numerical model include delivery of sediment to the shoreline by river flow rendered hypopycnal by ambient saline ocean water and near-shore sediment settling in a density-stratified field to build a (continental) shelf. Wave-induced sediment suspension from the bed of that shelf generates wave-supported, relative weak turbidity currents that plane off the shelf, and then deposit sediment onto the adjacent (continental) slope, causing seaward progradation of the clinoform into deep water. The presence of ambient saline water is a necessary condition for shelf formation. We show that these turbidity currents can generate cyclic steps on the slope. The second mechanism concerns the propagation of long-runout (100’s to 1000’s of km) turbidity currents that have the potential to emplace channelized submarine fan channels. We do this by formulating a two-layer model of turbidity currents that sequesters most of the sediment in the lower layer but drags nearly sediment-free water in the upper layer. The lower layer can reach an equilibrium (normal) state that can propagate indefinitely downstream on a constant slope with constant thickness and layer-averaged flow velocity. The upper layer can thicken indefinitely. A key feature of the model is the role of fall velocity as it fights against upward flux due to turbulent mixing. At higher slopes, the bottom-layer flow is Froude-supercritical and can be driven by sand, but at lower slopes it is Froude-subcritical and can be driven by mud.

## 5.4 Dynamics of natural landslides from numerical modelling and seismic inversion

Presenter: *Anne Mangeney, University Paris Cité, Institut Universitaire de France*

One of the major challenges facing our society is to cope with the increase in natural hazards caused by climate change, human activity and population growth. The frequency of heavy rainfall and changes in vegetation cover are intensifying in most regions, greatly increasing the risk of landslides and the tsunamis they generate.

Exact prediction of the time, location and precise characteristics of a landslide is generally out of reach. However, it is possible to anticipate hazards by numerically simulating a series of probable scenarios using granular flow models on realistic topographies. However, there are two major obstacles to the use of these models. Firstly, the frictional behavior of these natural flows remains highly enigmatic, and most models fail to describe processes that play an important role at field scale, such as the interaction between grains and a fluid phase. On the other hand, very little data is available on the dynamics of these flows. In this context, the analysis of landslide-generated seismic waves coupled with the development of mathematical, physical and numerical models of granular flows on complex topography opens a unique opportunity to address this challenge.

I will present recent studies we have carried out with mathematicians and physicists to quantify landslide dynamics in order to assess the associated hazards. A key aspect of this work is to successfully couple state-of-the-art numerical simulation of these complex rheological flows with seismic wave analysis, moving back and forth between laboratory and field scales. I will describe the challenges posed in terms of modeling, such as dilatancy effects in a grain/fluid mixture, wave-flow interaction, and the relevance of multilayer Saint-Venant-type approaches.

## 5.5 Sediment-Gravity Flows and the Morphodynamics of Continental Margins with Deformable Substratum

Presenter: *David Mohrig, Department of Earth and Planetary Sciences, The University of Texas at Austin, USA*
Contributors: *Xinggang Christopher Liu, Department of Earth and Planetary Sciences, The University of Texas at Austin, USA*
*James Buttles, Thomas Hess, Brandon Minton*

The transport characteristics of sediment-gravity flows building continental margins are measurably affected by the morphodynamics of these deep-marine systems. This is particularly true of margins that are partially composed of deformable substratum (salts and/or shales). In these settings, both margin-form and stratigraphy are the products of interactions between (1) sediment gravity flows that deposit and erode sediment composing the seafloor, (2) seafloor topography itself that guides these transporting currents, and (3) mobile substratum that shifts in response to an evolving differential loading, further shaping the overlying seafloor topography. This deformation can produce a variety of folds, horsts and grabens, and minibasins that influence sediment transport by ensuing currents. These feedbacks between currents, topography, and mobile substratum vary in space and through time, making it difficult to tease them apart using only seafloor topography or a final stratigraphy. Here we present results from physical modeling specifically designed to investigate these feedback loops in order improve our morphodynamic intuition of these deep-marine systems and to generate data sets for benchmarking numerical models.

## 5.6 Exploring Cohesive Sediment Transport Processes via Grain-Resolving Simulations

Presenter: *Eckart Meiburg, Department of Mechanical Engineering, UC Santa Barbara, USA*

We investigate the dynamics of concentrated suspensions of cohesive sediment via four-way coupled, grain-resolving direct numerical simulations. Towards this end, we focus on three generic configurations: 1) the settling of polydisperse cohesive sediment in quiescent water, 2) the flocculation and breakup of cohesive sediment in homogeneous isotropic turbulence, and 3) cohesive granular collapse.

For the settling of ploydisperse cohesive sediment, the simulations reproduce several earlier experimental observations by other authors, such as the accelerated settling of sand and silt particles due to particle bonding, the looser packing of the cohesive sediment deposits, and the consolidation process of the deposit. For cohesive sediment in turbulence, we observe a transient flocculation phase, followed by a statistically steady equilibrium phase. Flocculation proceeds most rapidly when the fluid and particle time scales are balanced and a suitably defined Stokes number is $O(1)$. The equilibrium floc size distribution exhibits a preferred size that depends on the cohesive number. We observe that flocs are generally elongated by turbulent stresses before breakage. For the submerged collapse of weakly polydisperse, loosely packed cohesive granular columns, we find that the cohesive forces act to prevent the detachment of individual particles from the main body of the collapsing column, reduce its front velocity, and yield a shorter and thicker final deposit. All of these effects can be accurately captured across a broad range of parameters by piecewise power-law relationships. The cohesive forces significantly reduce the amount of available potential energy released by the particles. Computational particle tracking indicates that the cohesive forces reduce the mixing of particles within the collapsing column, and it identifies the regions of origin of those particles that travel the farthest. The simulations furthermore provide complete information on the temporally and spatially evolving network of cohesive and direct contact force bonds during the collapse process.

# 6 Presentation Abstracts

## 6.1 Experimental Modelling of Rock Dumping through Vertical Pipes and Inclined Tunnels

Presenter: *Alan Cuthbertson, University of Dundee, UK*
Contributors: *Otto Neshamar, University of Dundee, UK*
*Øyvind Thiem, Statens vegvesen, Bergen, Norway*
*Peter Davies, University of Dundee, UK*

Results will be presented from a series of scaled laboratory experiments designed to model the dumping of graded rock masses, produced from tunnelling operations, into a quiescent fjordic water body via either vertical pipes or inclined tunnel shafts. The main environmental concern with this dumping process relates to the fate of fine suspended particulates present within the rock grain size distribution (GSD), and their potential release into the wider fjord that can impact on both wild and farmed salmon stocks. The laboratory experiments therefore consider the dynamic behaviour of the graded rock dumps both within the pipes or tunnels, and the nature of particle-laden plumes generated following their release at the pipe/tunnel exit into the water column. Results indicate that hindered fractional settling and size-segregation are the main physical mechanisms controlling rock mass deposition from vertical pipes, while equivalent dumps into inclined pipes behave as particle-laden gravity currents, with a more efficient release of the dumped rock mass (i.e. over shorter time periods) compared to the vertical pipe arrangement. Sequential single-shot mass dumps are also shown, for both dumping arrangements, to control the potential for wider release of fines through their re-entrainment back into subsequent particle-laden plumes. Finally, the scaling implications for planned full prototype scale dumping operations in natural fjordic water bodies are also considered from these idealized laboratory experiments.

## 6.2 The three-dimensional turbulent structure of steady state gravity currents

Presenter: *Gareth Keevil, University of Leeds, UK*
Contributors: *Caroline Marshall, Ed Keavney*

Gravity current structure has been extensively studied using laboratory and numerical methods. Much previous work has focused on lock-exchange type flows that typically result in an exaggerated current head and a distorted turbulence distribution. In most natural flows, the body of the flow forms the majority of the current. This study aims to quantify the three-dimensional turbulent structure of a range pseudo-steady state gravity currents.

Planar particle imaging velocity (PIV), shake-the-box particle tracking (StB) and acoustic measurements were used to investigate the body of pseudo-steady gravity currents, focusing on the turbulence structure and formation of coherent turbulent structures. These structures control the distribution of mass, momentum, and temperature, and potentially impact on erosion and deposition in particle laden flows. PIV was used to investigate a range of Reynolds numbers by considering various slopes with a constant influx, as well as a

constant slope with varying influx. StB was used to provide 3D characterisation of single Reynolds number flow. Acoustic measurements quantified several unconfined gravity currents with a range of topographical controls. The StB data describes experimentally the three-dimensional turbulent structure of the body of pseudo-steady gravity current flow for the first time. The data reveal the complex three-dimensional flow and internal waves present within gravity currents from a simple ducted domain, and that cross-stream and vertical flow velocities within these currents are of very similar magnitude.

A parallel set of unconfined physical experiments have revealed the presence of significant complexity within gravity currents partially bounded by topography, and lateral spreading of flows. These experiments provide insights into the formation and spatial distribution of distinctive bedforms (hummock-like and sigmoidal bedforms, sediment dispersal pattern) and process controls on onlap termination styles. We show that the lateral component of turbulence, and flow spreading, is an important component of gravity current structure.

## 6.3 Internal flow structure enhances the material transport of gravity currents

Presenter: *Sojiro Fukuda, University of Hull*

Turbidity currents, submarine particulate gravity currents, are the primary mechanics of material transport from shallow to deep marine systems. The observed turbidity currents exhibited highly stratified and well-channelized behaviour, contradicting the previous theory and numerical models. One of the critical challenges to tackling this enigma is the internal flow structure, which enables the well-channelized flow behaviour beyond the distal seafloor where the slope is extremely shallow, and thus, the flow is decelerating, or at best, equilibrium. Here, we gathered 70 years of flume experiments and direct observational data to develop an empirical flow stratification model of turbidity currents. Our machine-learning stratification model, trained by both natural-scale and laboratory-scale data, successfully demonstrated how turbidity currents maximise their material transport efficiency over the distal shallow slope, providing a possible explanation for the long-standing enigma of turbidity currents.

Contrary to the previous models, turbidity currents increase their material and momentum transport efficiency as they decelerate by modulating the velocity and concentration profiles as if turbidity currents have survival instincts. The strong correlation between velocity and concentration profiles plays a vital role in this mechanism. We concluded that the flow concentration profile thoroughly controls the flow velocity profile, especially in the lower half. In contrast, the flow velocity at the upper half shows a wider variety, presumably due to interference by ambient fluid, counter-current, or overspilling.

## 6.4 Inception, Maintenance, and Termination of Submarine Channels crafted by turbidity currents

Presenter: *Kyle Straub, Tulane University*

Channels are a key component of submarine fan morphology and preserved channel bodies help define their stratigraphic architecture. These channels guide fan forming turbidity currents and influence surface dynamics resulting in the construction of submarine fans on continental slopes and abyssal plains in deep-water settings. Modern observations of seafloor bathymetry, seismic data, and outcrop images point to an array of submarine channel shapes including meandering, distributive, and low sinuosity channels. Here we focus on non-meandering channels and leverage a depth-average model for turbidity currents to explore controls on the inception, maintenance, and termination of submarine channels. We expand on previous work that explored the very early stages of channel inception by using a numerical model that is known to produce complex and evolving distributary channel networks on fan surfaces. We test two hypotheses, 1) Froude and Rouse Number of turbidity currents set conditions necessary for the inception of self-formed submarine channels, and 2) Parameters such as, grain size distributions, sorting of sediments, flow mud content, flocculation of mud particles, and bedload transport set thresholds for erosion and sedimentation within submarine channels that influence their mobility during fan formation. We quantify emergent channel morphology including their aspect ratio and network statistics such as dimensionless distance between bifurcation nodes. Results from this work will aid stratigraphic predictions from a priori knowledge of boundary conditions and the inversion of paleo-hydraulics from preserved deep-water stratigraphy, which will aid the reconstruction of environmental signals.

## 6.5 Forward-modeling the transition of erosional-to-depositional cyclic steps by turbidity currents in the Rio Muni Basin

Presenter: *Peng Hu, Ocean College, Zhejiang University, China*
Contributors: *Yue Li, Ocean College, Zhejiang University, China*
*Chenglin Gong, China Petroleum University, Beijing, China*

We apply a state-of-the-art layer-averaged turbidity current model is applied to investigate the transition mechanism of erosional-to-depositional cyclic steps by turbidity currents in the Rio Muni Basin off the West Africa margin, where nine cyclic steps featuring a transition from the upstream erosion to the downstream deposition were identified. A series of numerical case studies revealed two distinct types of turbidity currents: high-speed and low-speed turbidity currents. For low-speed turbidity currents, the erosive capacity increases with flow velocity but is weak in transporting coarse particles; for the high-speed turbidity currents, the erosive capacity remains at its peak, with the erosion amount increasing with particle size in an erosive state. We compared hydrodynamic parameters of turbidity currents in literature, indicating self-acceleration turbidity currents are often in a high-speed state. On the contrast, it is shown that the concerned cyclic steps may be primarily shaped by low-speed turbidity currents, whereas the back-estimated turbidity currents obtained using the traditional bank-full assumption inversion method belong to high-speed type. Nevertheless, hydrodynamic parameters, such as Froude numbers and the trends in turbidity current thickness and flow velocity, are consistent with the parameters obtained from geological parameter inversion.

## 6.6 Inverse Analysis of Turbidity Currents Originated by Major Earthquakes and Tsunamis along the Japan Trench

Presenter: *Hajime Naruse, Kyoto University, Japan*
Contributors: *Cai Zhirong, INPEX*

The purpose of this study is to estimate the magnitude of past earthquakes by inverse analysis of turbidites deposited by turbidity currents of giant earthquakes and tsunamis origin, which occur once every several hundred to one thousand years by periodic trench earthquakes. The ocean bottom pressuremetry and the boring core samples off Tohoku region, Japan, indicated that the 2011 Tohoku-oki tsunami caused a large-scale turbidity current that deposited a turbidite over $100\ km$ wide and $200\ km$ long. IODP Expedition 386 drilled the Japan Trench and exhibited that the turbidites were also deposited by turbidity currents associated with several historic earthquakes such as 869 Jogan Earthquake. The inverse analysis on these geological records are expected to provide information on the source properties of these turbidity currents, which is useful to verify whether the past earthquakes were caused cyclically at the same subduction zone or not. Therefore, we developed an inverse analysis model of turbidite using a deep neural network (DNN). The inverse model in this study employed a forward model based on the horizontal two-dimensional shallow-water equation, and $500\ m$ mesh topographic data of the Japan Trench were used for the simulation. A deep neural network was trained with the artificial teacher dataset generated by more than $2{,}000$ iterations of the forward model calculation. The performance of the trained inverse model was verified using artificial test data, and it was found that the number of borehole core sites currently available was sufficient to estimate the hydraulic conditions of past turbidity currents.

## 6.7 Long runout of turbidity-currents in depth average models

Presenter: *Edward Skevington, Energy and Environment Institute, University of Hull, UK*
Contributors: *Robert Dorrell, Energy and Environment Institute, University of Hull, UK*

We develop the depth-average framework of modelling gravity currents to include the vertical structure of the currents in the energetics, and propose a parameterisation of this structure with depends on the strength of the turbulent kinetic energy (TKE). The inclusion of shape influences the dynamics of the current in non-trivial ways. Firstly, the threshold between sub-critical flows and super-critical flows can be shown to occur when the kinetic energy of the current equals the gravitational potential. Secondly, the production of TKE is boosted by the shape, aiding in keeping sediment in suspension. Thirdly, we include levee overspill in the model, and it is the slow dilute fluid in the upper reaches of the current which undergoes overspill leaving the fast, higher concentration core behind as the channel cross-section reduces, keeping the current in a supercritical state over long distances. Numerical solutions for turbidity-currents in the Congo canyon reveal that the combination of vertical structure and levee overspill result in long-runout currents, demonstrating that our model captures the essential physics for modelling real world systems.

## 6.8 Modelling and interpretation of the "slumping phase" of down-slope propagation of a lock-release particle-driven gravity current

Presenter: *Marius Ungarish, Technion Israel Inst. of Technology*

The ``slumping'' phase (stage) of an inertial two-dimensional horizontal and homogeneous lock-release gravity current (GC) is a clear-cut and well understood phenomenon, but the counterpart behaviour of particle-driven and/or down-slope GCs is more complicated and less understood. We briefly review the state-of-the art of modelling and interpretation of this flow. The major tool is a two-layer shallow-water (SW) model for the depth-averaged variables, whose predictions are compared with previously-published experimental data. In particular, we analyze the empirical conclusion of Gadal et al. (JFM vol 974, 2023) that the slumping displays a constant speed for a significant range of slopes and particle-sedimentation speeds. We focus on the question if and when the propagation speed $u_N$ of the nose (front) of the GC is constant during this process (there is consensus in the literature that a significant deceleration of $u_N$ appears in the post-slumping stage.) The SW theory predicts correctly the adjustment of the flow field during the slumping stage, but indicates that a constant $u_N$ appears only for the classical case ($\gamma = E = c_D = \beta = 0$) where $\gamma, E, c_D, \beta$ are the slope, entrainment and drag coefficients, and the scaled particle settling speed for a particle-driven GC. However, since $\gamma, E, c_D, \beta$ are typically small, the change of $u_N$ during the slumping stage is also small in many cases of interest. We show that in a system with a horizontal (open) top, as used in typical laboratory experiments, the height of the ambient increases along the slope, and this compensates for the loss of buoyancy due to particle sedimentation. Gaps of knowledge for further research are indicated.

## 6.9 Tsunamis transforming into particulate gravity currents: As seen from hybrid event bed deposits.

Presenter: *Patrick Sharrocks, University of Leeds, UK*
Contributors: *Jeff Peakall, Natasha Barlow, David Hodgson*

Here we show that tsunami flows can rapidly transform into particulate gravity flows when they enter standing bodies of water such as lakes. We synthesised the literature on tsunami deposits in coastal lakes to describe the standard sedimentary sequence and develop a depositional model for their formation. Results indicate that a standard sequence forms within a few hundred metres of the lake edge consisting of a thin sand layer overlain by a thicker organic-rich (and often mud clast-rich) muddy sand layer and often capped by a fine mud cap. The basal sand layer thins and fines inland, whereas the muddy sand layer is thickest in lakes further from the coast and at depth within these lakes. In lakes closer to sea level, repeats of the above sequence can be seen and the organic-rich muddy sand layers are thinner and often lack mud clasts.

The composition and characteristics of these deposits resemble hybrid event beds formed under transforming flows in submarine settings, where a debritic layer overlies a turbidite. Therefore, we propose a similar depositional process for tsunamis when they enter coastal lakes. A tsunami flow becomes increasingly dense as it entrains sediment overland, as recently shown for the Sendai plain, generating a density difference as the tsunami enters coastal lakes, this drives the formation of a particulate gravity current in the lake. This initially takes the form of a high-density turbidity current which transforms due to the erosion and entrainment of fine-grained lake sediment into a hybrid flow within the space of a few hundred metres. This rapid flow transformation produces the hybrid event beds seen in the sedimentary record. The speed of the flow transformation has important implications when considering particulate gravity currents in other depositional settings and the effect on the sedimentary archives of lakes.

## 6.10 High resolution multi-frequency acoustic backscatter inversion for turbidity current grain size and concentration

Presenter: *Steve Simmons, Energy and Environment Institute, University of Hull, UK*

Turbidity currents have been successfully monitored across a range of global settings using instruments deployed on moorings and frames deployed in the submarine channels. Inversion of acoustic backscatter acquired using acoustic Doppler current profilers (ADCP) has demonstrated how the sediment concentration structure of flows can be determined using a combination of backscatter, attenuation of the seafloor echo, and assumptions about the grain size distribution in suspension. These acoustic techniques have relied upon simplifications about the variability of the suspension grain size with height above the seafloor. Such assumptions are likely to be less valid when suspended sediment is dominated by larger particle sizes, such as sand. ADCP spatial resolution is also constrained by the size of the measurement volumes, which need to be sufficiently large to ensure the quality of the velocity measurements. Here, we present data from an analysis of turbidity current acoustic backscatter recorded with a calibrated Multi-frequency Ultrasonic Device (MUD) that was developed from a zooplankton imaging instrument. The MUD acquired backscatter on three different acoustic frequencies ($200\ kHz$, $796\ kHz$, $1250\ kHz$) at a high spatial resolution ($10\ cm$) during a short deployment ($<\ 3$ days) at a height of 10 metres above the channel axis of the Homathko branch of the Bute Inlet submarine channel system. The instrument captured the passage of several short turbidity currents in quick succession during the deployment in May 2018. We present suspended sediment results derived from the application of a multiple-frequency acoustic inversion of the backscatter recorded by the MUD. We compare the results to sediment concentrations derived from an inversion of the backscatter acquired with a 300 kHz ADCP on a mooring a short distance down channel.

## 6.11 Hydro- and morphodynamics of turbidity currents induced by river inflows into lakes

Presenter: *Daniela Vendettuoli, TU Wien, Austria*
Contributors: *Koen Blanckaert, TU Wien, Austria*
*D. Andrew Barry, École Polytechnique Fédérale de Lausanne, Switzerland*

Turbidity currents connect terrestrial sediment sources to deep-water sediment sinks. They do not only occur in oceans, but also in lakes and man-made reservoirs, where they are a major cause of sedimentation and capacity loss. Field measurements of turbidity currents remain scarce due to their notorious reputation of damaging instruments along their path. Recently, ADCP-based measurements of turbidity currents in ocean canyons were reported. Here, we present the first ADCP-based measurements of a turbidity current in Lake Geneva and its interaction with the lake bottom.

On 3 July 2018, a convective storm occurred in the high-mountain watershed of the Navisence, a tributary of the Rhône River situated about 80 km upstream of Lake Geneva. As a result, the Navisence supplied a high suspended sediment load to the Rhône River. Maximum sediment concentrations of $O(10\ kg/m^3)$ were measured at the hydrological measurement station located $6\ km$ upstream of the Rhône River mouth. Since the sediment-laden Rhône waters were denser than the lake water, they produced a turbidity current in the canyon carved by the Rhône inflow on the bottom of Lake Geneva. The characteristics of the turbidity current were measured with moored ADCPs at three locations along the canyon: at $1400\ m$, $2250\ m$ and $3500\ m$ from the river mouth.

The measurements revealed remarkable features. First, the peak discharge in the turbidity current at $1400\ m$ from the mouth was more than an order of magnitude larger than the Rhône discharge at the mouth, which suggests a massive pick-up of sediment from the lake bottom. Second, the maximum velocities in the turbidity current were more than $2\ m/s$, which is comparable to turbidity current velocities in much larger ocean canyons. Third, the turbidity current weakened between the measurement sites at $2250\ m$ and $3500\ m$ from the mouth.

## 6.12 Extreme erosion and bulking in a giant submarine gravity flow

Presenter: *Chris Stevenson, University of Liverpool, UK*

Sediment gravity flows are ubiquitous agents of transport, erosion, and deposition across the Earth's surface, including terrestrial debris flows, snow avalanches, and submarine turbidity currents. Sediment gravity flows typically erode material along their path (bulking), which can dramatically increase their size, speed and run-out distance. Hence, flow bulking is a first order control on flow evolution and underpins predictive modelling approaches and geohazard assessments. Quantifying bulking in submarine systems is problematic due to their large-scale and inaccessible nature, complex stratigraphy, and poorly understood source areas. Here, we map the deposits and erosive destruction of a giant submarine gravity flow from source to sink. The small initial failure ($\sim 1.5\ km^3$) entrained over 100 times its starting volume: catastrophically evolving into a giant flow with a total volume of $\sim 162\ km^3$ and a run-out distance of $\sim 2000\ km$. Entrainment of mud was the critical fuel, which promoted run-away flow growth and extreme levels of erosion.

## 6.13 Simulating Stratigraphic Dynamics: From Physical Experiments to Digital Visualizations

Presenter: *Carolina Holz Boffo, Universidade Federal do Rio Grande do Sul, Brazil*
Contributors: *Rafael Manica, Tiago Oliveira, Keila de Holleben, Lucas Pires, Lucas Bergue, Ana Luiza Borges, Thaís Empinotti, Paulo Paraizo*

This study involves a physical simulation to test conceptual stratigraphic models representing a complete cycle of relative base-level variation. The aim is to analyze the dynamics of sedimentary deposits combining the parameters related to the development of stratigraphic architecture. The simulated sedimentary environment features an estuary influenced by fluvial input, which facilitates sediment transfer to the basin, particularly during forced regression and lowstand stages when drivers enhance activity in deep-water regions. The goal is to establish the experimental conditions necessary to test conceptual stratigraphic models and develop digital visualizations to assist practitioners of high-resolution geological characterization and modeling. The model is scaled at $1{:}\,20{,}000$, representing a prototype measuring $50{,}000\ m$ in length, $30{,}000\ m$ in width, and $1{,}300\ m$ in depth. Experiments are conducted in a tank measuring $2.5\ m$ wide, $3.0\ m$ long, and $0.7\ m$ deep, with a continental shelf and slope geometry constructed using mineral coal and limestone. Sedimentary variations are simulated through different discharge rates, volumetric concentrations, and sand and mud proportions, reflecting base-level fluctuations conceptualized from stratigraphic models and regulated by fluvial input and water-level variation within the tank. During the experiments, timelapse images, discharge data, and water level variations are recorded. Bathymetric surveys are conducted at various stages of the stratigraphic cycle to identify erosional and depositional areas. After the experiments, the tank is drained, and the resulting deposit is dried and dissected for analysis. Each slice is photographed and sampled to build stratigraphic and textural profiles. The collected data are digitally processed to create a 3D/4D stratigraphic visualization, extract volumes for each deposit interval, and characterize the internal geometrical and textural aspects, as well as the sand/mud ratio and distribution. Correlating the input parameters with the resulting distribution of geometries and architecture enhances our methods for evaluating the evolution of depositional systems, providing important insights into the complex dynamics of sedimentary environments.

## 6.14 Impact of sediment concentration on the hydrodynamic and depositional features of sediment gravity flows

Presenter: *Rafael Manica, Universidade Federal do Rio Grande do Sul, Brazil*
Contributors: *Carolina Holz Boffo, Daniel Bayer da Silva, Ana Luiza Borges, Tiago Oliveira, Paulo Paraizo, Thaís Empinotti*

The comparison of results from $12$ fully instrumented experiments enabled the identification of hydrodynamic behaviors exhibited by sediment gravity flows. Variations in suspended particle concentration significantly impact the driving forces, thus altering the sediment transport mechanism and depositional processes. These experiments were conducted in a flat flume measuring $15.0\ m$ in length, $0.4\ m$ in width, and $1.0\ m$ in depth, supplied by a raised mixing reservoir. A total of $200$ liters of mineral coal mixtures, with volumetric concentrations ranging from $1$ to $42\%$, were continuously injected at a rate of $50\ L/min$. Throughout the experiments, imagery was captured via video cameras and medical ultrasound, while velocity and concentration profiles were measured using UVP and UHCM probes. After the experiment, deposit samples were collected along the flume and grain size analysis was performed. The analyses unveiled hydrodynamic modifications in sediment transport and deposition correlated with volumetric concentration. Turbulence emerges as the predominant sediment-transport mechanism for flows with concentrations up to $7.5\%$. Within turbulent flows, grain-by-grain particle setting deposition is noticeable, signifying an efficient sorting mechanism where coarse sediments settle first, while fine particles remain suspended for subsequent deposition. An increasing in volumetric concentration, i.e., average between $10$ to $20\%$, results in the stratification of the flow, where a higher concentration inner layer develops a non-cohesive mass transport-like aspect at the base of the current and a turbulent outer layer with a mixture layer at the top. Deposits resulting from stratified flows consist of two distinct layers: a poorly sorted, massive base and a well-sorted fine mud layer on top. Additionally, vertical pipes and dishes are occasionally identified within the massive deposits. For flows with concentrations exceeding $30\%$, turbulence is suppressed. These high-concentration flows exhibit low velocities, transitioning the flow to be driven solely by inertial forces, resulting in homogeneous deposits without observable sorting. An important result to highlight is that intermediate concentrations, counterintuitively, exhibit greater transport efficiency, reaching more distal regions in the flume, what brings important insights for the interpretation of related natural deposits.

## 6.15 Turbidity current–contour current interaction and their combined sediment transport

Presenter: *Pelle Adema, Utrecht University, Netherlands*
Contributors: *Joris Eggenhuisen, Elda Miramontes, Ricardo Silva Jacinto*

Turbidity currents are the main agent transferring sediment, carbon, nutrients and pollutants (e.g. micro-plastics) from the continents to the deep sea. They flow through submarine canyons and channels, connecting the continents to the oceans. Along their trajectory, these flows may interact with a suite of oceanographic processes such as geostrophic contour currents forming a mixed system, entraining material from the turbidity current into the large-scale ocean system. Various models have been published that hypothesize how these flows interact dynamically and how they build morphologies, but these models are inferred from deposits and an in situ measurement of combined flow does not exist.

We conducted experiments showing how turbidity currents and contour currents interact and how these combined flows interact with different mixed system channel morphologies occurring in nature. Furthermore, we study how combined flows transport and deposit sediment differently from turbidity currents without contour currents present. Our experiments show that the secondary flow of the experimental turbidity currents is bi-cellular. Contour currents collapse the bi-cellular structure into a single cell that is constrained to the downstream channel margin. The secondary circulation affects the grain-size distributions in the flow and after deposition in the channels and on the overbanks. Grain-size data from the channels and the overbanks shows a clear difference between the experiments with a contour current, compared to the runs without contour currents. The overbank and channel deposits separate in two clusters when a contour current is present and are spread on a continuum from channel to overbank without a contour current. Together, these findings suggest that we need to consider mixed systems with a new depositional model that differs from classic turbidite depositional models.

## 6.16 Low-gradient lobes physical experiments: hydrodynamics approach and bedforms

Presenter: *Débora Koller, Universidade Federal do Rio Grande do Sul, Brazil*
Contributors: *Rafael Manica, Juan Fedele*

Three experiments of formation of low-gradient lobes and related sedimentary structures (bedforms), designated E1, E2, and E3, were performed in an 8-meter-long and 2.7-meter-wide 3D tank. E1 was run on the fixed bed, while E2 and E3 were run on the previous deposits. Turbidity currents consisted of mixtures of $10\%$ by volume ($90\%$ coal and $10\%$ kaolin) flowed at a discharge rate of $100\ L/min$. Each experiment lasted around $35\ min$. Velocities were recorded by UVP probes at $0.5$, $1.75$, $2$, and $3\ m$ from the point of unconfinement, along a central line and along two lateral lines located 1 meter each side. Concentration measurements were conducted using a movable metal beam positioned transversely to the flow, on which three vertical profiles, each with five siphons, were installed. The gathered data enables the calculation of layer-averaged values of velocity, concentration, and flow thickness, using the equations proposed by Ellison and Turner (1959). Additional parameters, such as shear stress, Froude, and Reynolds number will be also calculated. Imaging was performed using external cameras and laser scanning of the deposits. The study revealed that the flow parameters exhibit substantial spatial variability. We observed a rapid decay of flow velocity and concentration values, caused by the deposition of the sediments, mainly close to the unconfinement area. Moreover, flow thickness increases downstream because of ambient water entrainment. Bedforms such as ripples, dunes and antidunes were observed. Preliminary results indicate that high-velocity and high-concentrated flows induce higher shear stresses, showed to be responsible for the generation of larger and more pronounced bedforms. The study will also incorporate hydraulic correlations with data from deposit laser scanning and grain size analysis of both the deposits and concentration samples.

## 6.17 Challenging the turbidity current maximum run-up paradigm: novel numerical models based on new experimental results

Presenter: *Mia Hughes, University of Leeds, UK*

Turbidity currents interact strongly with seafloor topography as a result of their relative density and associated gravitational influence being $2 - 3$ orders of magnitude smaller than in terrestrial systems. Marked run-up of turbidity currents on slopes poses a hazard to seafloor infrastructure, and leads to distinctive depositional patterns. Understanding these phenomena hence requires numerical models that can estimate the maximum run-up height of a turbidity current interacting with different topographic configurations. For a turbidity current flowing from flat to planar upslope topography, the existing numerical models of its maximum run-up height are essentially 2D in scope and hence do not account for the possibility of an oblique incidence angle between the flow and the slope. Recent new experiments at the Environmental Fluid Dynamics Laboratory (Leeds) studied unconfined saline gravity currents meeting oblique planar topography with a range of gradients and incidence angles, shedding light on how these variables affect the flow, including the maximum run-up height. Novel numerical models are presented for predicting maximum run-up height as a function of both the gradient and incidence angle, comparing the models to the newly observed data. Such models provide realistic estimates of run-up heights for flows on three-dimensional slopes typical of natural systems.

## 6.18 Self-confinement by submarine debris flows: process insights from seabed mapping and physical experiments

Presenter: *Yan Li, University of Leeds, UK*
Contributors: *David Hodgson, Jeff Peakall, Weijian Gao, Helena C. Brown, Gareth M. Keevil, Mike Clare*

Submarine landslides can destroy seabed infrastructure and generate tsunamis, and pose a threat to coastal communities. The volume and processes of a submarine landslide emplacement are important parameters to simulate the formation and propagation of tsunamis. Submarine landslide can bulk-up in volume considerably, and it is important to understand how the flow entrains substrate to improve predictions of their tsunamigenic potential.

Multiple submarine landslides have been documented offshore NW Australia. Based on seismic-well ties, the distribution and emplacement process of these landslides is attributed to the presence of weak layers, characterised by high water content, high porosity, and low shear strength. From seismic reflection data, one submarine landslide is interpreted as a debrite with kms-long grooves and associated blocks. Detailed mapping reveals that this flow self-confined through sequential basinward deposition of debrite lobes, which led to incision ($45\ m$), and the formation of steep lateral margins ($5°$). The ratio of deposited ($V_d$) to initially evacuated ($V_e$) sediment volume is up to $2.9$, which suggests most of the landslide volume came from the substrate during emplacement, rather than the headwall region.

Physical experiments will be carried on in the Sorby Environmental Fluid Dynamics Laboratory, using a layered protolith with different characteristics (e.g., grain-sizes and cohesivity) to explore how coherent flow interacts with substrates. Our aim is to further understand how the submarine landslides gradually cut down and form steps, and how the flow interacts with the underlying substrate and the front confined strata.

## 6.19 A new frontier in the study of particulate transport and mixing: The Stratified Flow Flume

Presenter: *J. Leonardo Corredor Garcia, Energy and Environment Institute, University of Hull, UK*

Particle transport is a common feature of most, if not all, flows in nature. From river flow, gravity currents, estuarine dynamics, to snow avalanches, among others; the fate and behaviour of particulate matter governs nutrient exchanges, pollutant transport, sediment deposition and hydrogeomorphological processes, in these environments. Currently, closure parameters in numerical models for sediment mixing (e.g. the Advection Diffusion Equation) rely on assumptions of Fickian dispersion with sparse experimental basis. Specifically, space-and-time resolved velocity, density and particulate concentration data are needed to resolve turbulent flux terms and test the Fickian hypothesis in models of particulate transport.

Recent developments have allowed flow visualisation and space-time quantification of velocity and temperature fields, via optical techniques such as Particle Tracking Velocimetry (PTV) and Laser-Induced Fluorescence (LIF) respectively. A state-of-the-art experimental rig that integrates the foregoing optical techniques, with a novel flume system comprising 6 layers, that permit individual configurations of velocity, and temperature (as a parameter or as a proxy for density variations) has been built in the University of Hull and named the Stratified Flow Flume (SFF).
This paper presents the capabilities of the SFF, including its ability to control velocity and temperature across all interacting layers. Results from point-based temperature and velocity checks using a thermal gauge and an Ultrasonic Velocity Profiler (UVP), show that a stable output of different

flow and temperature profiles was attained to a remarkable degree of accuracy. It should be noted that limitations in this point-measurements meant that considerable deviations were recorded for flows with considerable shear, and temperature jumps, wherein significant mixing is expected. Finally, preliminary results from three-dimensional PTV tests are presented in the form of particle tracks to showcase the novel datasets to be obtained from this system.

## 6.20 Permeability of gas-particle mixtures under shear

Presenter: *Natalia Lipiejko, Lancaster Environment Centre, Lancaster University, UK*
Contributors: *Thomas J. Jones, Lancaster Environment Centre, Lancaster University, UK*

Gas-particle mixtures occur in a range of hazardous geophysical flows such as pyroclastic density currents, snow avalanches and landslides. They have an ability to travel great distances, which has been often attributed to the presence of positive internal pore pressure, which enhances the flowability of granular mixtures. One factor governing the fluidisation behaviour and pore pressure evolution of a granular column is its permeability — the ability of the gas to move through the particle column. Our current knowledge of gas-particle permeability is mainly limited to static conditions, however, most of the geophysical processes are dynamic phenomena, where parameters such as the shear-rate change with both time and space.

Here, the effects of shear-rate on the permeability of gas-particle mixtures were studied through novel experiments where a granular mixture is simultaneously sheared and fluidised whilst the gas flow rate and pressure are measured. All the granular columns start to expand upon increasing the air velocity, however, columns sheared at higher rates require greater air velocities to exhibit bubbling. As the air velocity increases, the pressure gradient across non-sheared granular columns increases linearly until it reaches a maximum value, slightly decreases, and then plateaus. Conversely, for high shear-rates, the pressure gradient continuously increases with increased air velocity, never reaching a maximum value or a plateau. The pressure gradient data were analysed alongside the videography in terms of the minimum fluidisation velocity and the minimum bubbling velocity, and both were found to be greater for higher shear rates. Consequently, our results show that increased shear increases the permeability of a granular column. The experimental data also suggests that in order to accurately describe the evolution of the pressure gradient across a sheared granular column, processes in the vertical as well as radial plane need to be taken into account.

## 6.21 Spontaneous unsteadiness in pyroclastic density currents and the impact on volcanic stratigraphy

Presenter: *Rebecca Williams, University of Hull, UK*
Contributors: *P. Rowley, M. Johnson, T. Johnston, N. Dowey, D.R. Parsons, A. Provost, O. Roche, G. Smith, N. Walding*

Pyroclastic density currents (PDCs) are often inferred to be unsteady, experiencing variations in current dynamics such as velocity at a given point through time. This has been inferred from interpreting deposits that appear to show evidence of transient current conditions and through observations of PDCs which appear to show pulsatory behaviour in sustained currents. This unsteadiness is often inferred to be related to fluctuations at source as the generation mechanisms of PDCs are inherently unsteady. For example, they may be formed by progressively collapsing lava domes, or through variably collapsing eruption columns that wax and wane as the eruption progresses.

Analogue experiments on aerated granular currents have revealed that current unsteadiness may be spontaneously generated within the current. This study explores how current unsteadiness is generated in sustained, aerated granular currents and the impact this has on current behaviour and deposit formation. Unsteadiness manifests as pulses generated at different stages of current propagation. We investigate unsteadiness in both mono- and polydisperse mixtures, and the relationship of the generation and proportion of pulses with particle segregation and current stratification. Particle segregation and sorting processes in thin, fluidised grain flows is highly efficient. The formation of poorly-sorted, massive, structureless deposits would therefore require significant vertical mixing in the current. This raises challenges to some of the existing paradigms used to interpret lithofacies in the rock record.

Finally, this work suggests that pulsatory behaviour and energy fluctuations are a fundamental yet overlooked process in PDCs which may exacerbate their mobility and destructive force. Addressing this gap is critical to improving hazard models and reducing the risk posed by PDCs.

## 6.22 Assessing the impact of topography on pyroclastic density currents

Presenter: *Jordan Chenery, Energy and Environment Institute, University of Hull, UK*
Contributors: *Rebecca Williams, Natasha Dowey, Pete Rowley, Rob Thomas*

Pyroclastic density currents (PDCs) are hazardous volcanic flows that can travel at high velocities (of up to $200\ km/h$) over great distances (in excess of $10 - 100\ km$) and have the potential to surmount topographic highs. Topography can deflect or reflect PDCs, and topographic barriers are sometimes used to delineate inundation areas in hazard assessment. However, how PDCs interact with topography is not yet fully understood. Past experimental studies have found that all or some of an unfluidized, analogue current can overtop topographic barriers depending on the ratio of flow thickness to barrier height, and the momentum of the flow. But the effect of topography on fluidised currents has not been investigated.
Here, we set out a new project that aims to quantify the effects of different topographic barriers (varying in height, slope angle, and obstacle location) on flow velocity, runout length, and deposit characteristics of aerated to fully-fluidised dense-granular currents (analogous to dense, granular PDCs) in a novel experimental flume. Further, analysis of depositional processes and the resultant analogue deposits will explore (1) the effects of different barriers on PDC deposit architecture and (2) the effect of dynamic topography (e.g. modification by progressive aggradation) on current propagation.

Initial findings suggest that topographic obstacles affect the flow characteristics of a dense-granular current as well as the resultant deposits, and that the overall runout length of the current is shorter if it has been impeded by a topographic obstacle. Next steps will involve a series of experimental runs to quantify the influence of the ratio of flow thickness to barrier height, topographic shape, and obstacle location relative to flow axes, upon a gas-fluidised, channelised granular current. Improved understanding of how topography affects the flow characteristics of PDCs will better inform hazard modelling and management strategies.

## 6.23 Distribution of volcanic blocks in the deposits of block-and-ash flows

Presenter: *Thomas Johnston, University College Dublin, Ireland*
Contributors: *Claire Harnett, School of Earth Sciences, University College Dublin, Ireland*
*Pete Rowley, School of Earth Sciences, University of Bristol, UK*
*Nick Varley, Facultad de Ciencias, Universidad de Colima, México*
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Lava domes form when viscous lava accumulates inside and around a volcanic vent. Lava domes can be generated by a wide range of magma compositions; and are unstable and prone to collapse. Dome collapses can generate block-and-ash flows (BAFs), which are largely gravity-driven currents that can include an explosive component; BAFs are typically low volume and often include dense, juvenile blocks with non-pumiceous ash. Blocks can sometimes be several metres in size and may form a volumetrically significant portion of the flow.

In July 2015 a rapidly grown lava dome on Volcan de Colima collapsed and generated a block-and-ash flow. This block-and-ash flow had a large volume and runout distance. There were two sustained block-and-ash flows which occurred over a short period of time ($18\ hours$) and travelled down the Montegrande Barranca with overbank flow into the San Antonio barranca. The block-and-ash flow consisted of three main components: juvenile lava dome material, older lithic fragments and crystals derived from the larger components.

We undertook fieldwork to investigate these valley-constrained deposits, in particular to establish trends in grain size and componentry as a function of distance from the flow source. The block-and-ash flow deposits have since been scoured by rainfall and lahar events. We undertook drone imagery of these exposed deposits and determined grain size distribution using image analysis software. Understanding grain size trends is vital as these trends can provide insights into flow conditions and the upper grain sizes ($> 64\ mm$) have previously been understudied. Understanding trends in componentry can indicate the source of the sediment, which has important implications for flow dynamics through factors such as temperature, density, porosity and rheology.

## 6.24 Volcanic umbrella clouds: from fundamental physics to operational forecasting

Presenter: *Chris Johnson, University of Manchester, UK*

Volcanic eruptions frequently produce fine ash, which is carried into the atmosphere and dispersed by the wind. Volcanic ash can pose a significant hazard to aviation, because even very small concentrations of ash can cause significant damage to jet engines. Several encounters between passenger jets and volcanic ash in the 1980s and 90s resulted in failure of all engines in flight, prompting the creation of Volcanic Ash Advisory Centres to monitor and forecast ash. Modelling of volcanic plumes and the dispersal of ash is therefore an area of practical, as well as scientific interest. Large volcanic eruptions often generate an 'umbrella cloud', a large cloud in which buoyancy forces push ash and gas away from the volcano. The dynamics of these clouds, and their interaction with meteorological wind, are still quite poorly understood, and are not well incorporated into ash forecasts. In this talk I describe some mathematical modelling of wind-blown umbrella clouds, modelling the cloud as a well-mixed intrusion into the stratified atmosphere. Solutions to a depth-integrated model for this intrusion reveal that drag quickly dominates its behaviour, and point the way to a simplified version of this model that is fast enough to use for operational ash forecasting. This is tested in the 'NAME' volcanic ash and transport model developed by the UK Met Office, and shows good agreement with satellite observations of ash clouds.

## 6.25 Internal Solitary Wave Shoaling; the effect of stratification and a new diagnostic tool to understanding mixing

Presenter: *Magda Carr, Newcastle University, UK*
Contributors: *Peter Davies, Sam Hartharn-Evans, Marek Stastna*

Internal solitary waves (ISWs) are finite amplitude waves of permanent form that travel along density interfaces in stably stratified fluids. They owe their existence to an exact balance between non-linear wave steepening effects and linear wave dispersion. They are common in all stratified flows especially coastal seas, straits, fjords and the atmospheric boundary layer. In the ocean they can attain amplitudes as large as $250m$ and speeds of up to $2\ m/s$. Whilst ISWs can travel considerable distance over a flat bottom without change of form, under certain conditions, such as when shoaling, their form can change considerably. As they do so, dissipation produced by the motion of breaking waves, both in the benthic boundary layer and the pycnocline, is identified as a key process in the global cascade of energy from global-scale mechanical forcing to dissipation.

In this presentation a combined experimental and numerical study will illustrate the effect of stratification form on the shoaling characteristics of ISWs propagating over a smooth, linear topographic slope. It is found that the form of stratification directly affects the breaking type (fission, collapse, plunge, surge) associated with the shoaling wave. In addition, a new diagnostic tool for understanding mixing in stratified fluids will be presented. Paired histograms of user-selected variables are employed to identify mixing fluid and are then used to display regions of fluid in physical space that are undergoing mixing. The method identifies differences in the mixing processes associated with different ISW breaking types, including differences in the horizontal extent and advection of mixed fluid.

Hartharn-Evans SG, Carr M, Stastna M, Davies PA. Stratification effects on shoaling internal solitary waves. Journal of Fluid Mechanics. 2022.
Hartharn-Evans SG, Stastna, M, Carr M. A new approach to understanding fluid mixing in process-study models of stratified fluids. Nonlinear Processes in Geophysics. 2024.

## 6.26 Buoyant granular column collapses

Presenter: *Herbert Huppert, University of Cambridge, UK*

We will present a study of fluid-particle interactions within complex granular-fluid systems such as particle-driven gravity currents. The dynamics of granular avalanches have similarities with natural geophysical flows, such as debris flows, landslides, and pyroclastic flows, whose instability, rheology, and deposition morphology are closely related to behaviours and particle scale dynamics of granular materials. We will discuss results obtained from coupled Lattice-Boltzmann discrete element method (LBDEM) simulations to explore the physics of buoyant granular column collapses in a subaqueous environment. We will further extend our observations and analyses to investigate the behaviour of natural flows, such as the propagation of volcanic clouds. We will indicate that the dynamics of these buoyant granular flows exhibit a similar scaling as the volcanic cloud propagation in Tonga, and the scaling transition demonstrates a regime change both within the granular system and on the boundaries between fluid and grains. This work further extends the scaling law of granular column collapses to examine the condition when particles are lighter than their ambient environment, and also to help shed light on the dynamics of similar airborne geophysical flows.

## 6.27 Lattice Boltzmann method-based massively parallel simulations of dilute gravity currents

Presenter: *Amirul Khan, University of Leeds, UK*

The Lattice Boltzmann method (LBM) provides a unique platform for computational modelling of high Reynolds numbers dilute gravity currents. This numerical approach is well known for its suitability for harnessing the computing power of massively parallel computing systems. This study introduces two LBM models applied to lock-exchange dilute gravity currents, where the largest turbulent length scales are directly resolved. We perform 3D simulations using graphics processing units (GPUs). These simulations have been corroborated against experimental results and high-resolution simulations for Reynolds numbers as high as 30,000. The LBM model demonstrates comparable accuracy to traditional large-eddy simulation (LES) models in predicting essential flow attributes. A cautious evaluation of computational efficiency compared to conventional methods shows that our computational framework can decrease simulation times by two orders of magnitude. As a result, it serves as a promising groundwork for creating depth-resolving computational models that capture the flow details and complexity found in environmental gravity currents.

## 6.28 Transport by waves and turbulence: Dilute suspensions in stably stratified plane Poiseuille flow

Presenter: *Charlie Lloyd, Energy and Environment Institute, University of Hull, UK*

Stable stratification is a key control on the dynamics of sediment laden flows. Here we investigate the transport of negatively buoyant passive sediment in a stably stratified plane Poiseuille (or channel) flow using numerical simulation. The flow is stratified by a temperature field with a fixed temperature difference between the upper and lower walls, leading to a flow comprised of a buoyancy dominated channel core with active near-wall turbulence. Strong buoyancy forces in the core have a profound impact on sediment transport, leading to two-layer sediment concentration profiles with concentration gradients increasing with sediment settling velocity, $V_S$. $V_S$ has a considerably larger influence on concentration profiles and higher order statistics when the flow is stratified. However, when scalar statistics are appropriately scaled by either $\theta_\tau$ for temperature or $V_S\,\bar{c}$ for sediment, where $\theta_\tau$ is the thermal shear temperature and $\bar{c}$ is the vertically varying sediment concentration, all scalars collapse to near common vertically varying profiles. Collapse is explained by revisiting the gradient diffusion hypothesis, which links vertical scalar fluxes to their mean vertical scalar gradients. Agreement between scalar statistics is less good in the core of the channel; differences between vertical turbulent diffusivities of sediment and temperature increase with increasing $V_S$, reaching $20\%$ for $V_S = 0.02$. We hypothesise that these discrepancies arise due to a departure from the linear gradient diffusion hypothesis, where large concentration gradients in the core coincide with large-scale mixing events. Predictions using the gradient diffusion hypothesis are expected to worsen with further increases to settling velocity.

## 6.29 Flow criticality in meandering slope channels

Presenter: *Benjamin Kneller, University of Aberdeen, UK*

The current consensus is that turbidity currents in slope channels are either supercritical, or alternate between super- and subcritical states as they traverse cyclic steps. However, it has been argued that on lower gradients, the long run-out of turbidity currents is indicative of negligible entrainment, and thus of subcritical flow.

Bulk Richardson (or Froude) numbers are often used as indicators of the degree of entrainment of ambient water (based on wholly empirical relations), and therefore as a measure of the stability of the stratification of the current. This is problematic, since Froude numbers of unity do not necessarily correspond to a critical value of gradient Richardson number, a truer measure of stability. Moreover, specific energy arguments imply that the critical Froude number may not be unity.

Recent direct numerical simulations suggest the existence of two radically different flow states: ‘supercritical’, with vigorous mixing due to instabilities, and a progressive vertical density decrease; and ‘subcritical’ state, with a lower, fully turbulent and more or less uniform layer, separated from a weakly or non-turbulent much more dilute upper layer across a steep density gradient. Significantly, the lower layer behaves similarly to an open-channel flow. It is suggested here that meandering channels form under this ‘subcritical’ state, and the thickness of the lower layer is the determinant of channel depth. The dilute nature of the upper layer means that relatively little overbank sedimentation should occur under these conditions. This flow structure is quite different from the classic gravity current structure, which some recent numerical and experimental modellers have termed ‘supercritical’, even though numerous studies have shown such flow structure in flows with bulk Froude numbers less than unity. This flow state may be more characteristic of aggradational channels.

## 6.30 Numerical simulation investigation of gravity currents using OpenFOAM and Incompact3D in channelized and open configurations for the study of deposit morphology.

Presenter: *Bruno Alvarez Scapin, Pontifical Catholic University of Rio Grande do Sul, Brazil*
*Contributors: Karina Ruschel, Pontifical Catholic University of Rio Grande do Sul, Brazil*

The Laboratory of Turbulent Flow Simulation at PUCRS (LASET) has over a decade of expertise in numerical modeling gravity currents using Direct Numerical Simulation (DNS) and Implicit Large Eddie Simulation (iLES) using the high-order open-source numerical solver, Xcompact3D, which is based on Finite-Difference Discretization Methodology, and recently, we have been using the open-source code OpenFOAM, that is based on the Finite Volume Methodology, which also allows working with more complex geometries and analysis domains). Within the scope of this study, the primary discoveries of the research group are elucidated, with a predominant focus on numerical simulations pertinent to gravity currents, examined under two predominant configurations within our laboratory: channelized flow and open basin, both utilizing the lock-release method. In the context of channel and basin configurations, the simulation of gravity currents can provide valuable insights into the flow dynamics and the influence of different parameters, such as Reynolds number, on the entrainment and propagation of the current. In both configurations, the impact of various parameters on the morphology of the deposit, such as the slope of the bottom, the dimensions of the lock-release region, and the diameter of the particles, was rigorously assessed. Xcompact3D and OpenFOAM are two well-established computational fluid dynamics tools that have been widely used to simulate gravity currents with a high fidelity of lobe-and-clefts structures and map deposition. Herein, we propose a function to ascertain the extent of gravity current propagation and provide a comprehensive overview of the findings derived from the laboratory numerical investigations, as well as incorporating some machine learning and computer vision techniques for the analysis of gravity current behavior.

# 7 Poster Abstracts

## 7.1 When the levee breaks: Deep-ocean channel-wall collapse order of magnitude larger than any other documented

Author: *Adam McArthur, Turbidites Research Group, University of Leeds, UK*

Submarine channels are the largest conveyors of sediment on Earth, yet little is known about their stability in the deep-ocean. New insights from seafloor and subsurface datasets are beginning to show that mass-transport deposits (MTDs) derived from channel wall failures may be large-scale, can damn channels, and their emplacement has implications for subsequent flows through a channel.
Here, 3D seismic data from the deep-ocean Hikurangi channel-levee system, offshore New Zealand, reveal the largest channel-wall failure yet documented. Collapse of both channel-walls along a 68 km stretch created a mass-transport deposit of 19 km3, containing 4 km long blocks. Emplacement of this MTD eroded and deformed earlier channel deposits, resulting in imbricated channel-fills being transported across and down-stream. The topography on the MTD top guided subsequent flows and the location of later channel routeing and deposition. Channel-walls typically collapse piecemeal, but here synchronous failure of both channel-walls and landslide erosion of the seafloor is documented, requiring a new process model for large-scale channel-wall failure.

Mass-failure on this scale poses an under-appreciated risk to seafloor infrastructure both within channels and over regions extending twice the channel width into their overbank. Hitherto, channel-wall failures of this size are unrecognised in abyssal plains; its scale changes our understanding of how channel-levee systems are constructed and how they conduct sediment, carbon and pollutants into the deep-ocean.

## 7.2 Rheology of bimodal gas-particle mixtures: the role of particle volume fraction and particle size distribution

Author: *Natalia Lipiejko, Lancaster Environment Centre, Lancaster University, UK*
Contributors: *Thomas J. Jones, Lancaster Environment Centre, Lancaster University, UK*

Gravity-driven geophysical granular flows are one of the most lethal natural hazards. One of the reasons for the hazardous and devastating nature of such flows is their ability to travel great distances. Extensive research has been conducted on the flow dynamics and their internal structure, however, existing rheological models do not fully capture the complex physical processes. Yet, this knowledge is crucial to accurately forecast the run-out distance of these hazardous flows. Owing to the complexity and unsteadiness of the flows, advances in understanding usually involve exploring the effects of the individual flow properties (e.g., particle volume fraction, particle size distribution, mean diameter) on its rheology.

Here, we contribute to this knowledge by studying the effects of the particle volume fraction and the particle size distribution on the rheology of granular mixtures through rheological measurements on variably fluidised monodisperse and bimodal granular mixtures. Granular mixtures comprise different proportions of glass beads of diameter $355 - 500\ \mu m$ and $63 - 90\ \mu m$. Preliminary results show that regardless of the particle size distribution, all the granular mixtures have lower viscosity when fluidised at higher flow rates, i.e., at lower particle volume fraction. Furthermore, the viscosity of a non-fluidised $50{:}\,50$ (small-to-large glass beads ratio by mass) bimodal mixture, despite having a higher particle volume fraction, is lower than the non-fluidised monodisperse columns. Further experiments will include rheological measurements on bimodal granular mixtures with the aim of producing a rheological model illustrating the effects of bimodality on granular rheology.

## 7.3 Pyroclastic density current dynamics though particle image velocimetry (PIV) of analogue experiments

Author: *Symeon Makris, British Geological Survey (BGS), Edinburgh, UK*
Contributors: *Eric C.P. Breard, School of Geosciences, University of Edinburgh, UK*
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Pyroclastic Density Currents (PDCs) are among the most lethal volcanic processes, consisting of hot gas-particle flows that result from the collapse of volcanic eruption columns, lava domes or pyroclastic material on volcanic flanks. These flows comprise a dense basal granular avalanche, which carries most of the mass and momentum, and an overlying dilute ash cloud. The ability of PDCs to entrain and mobilise material along their path further increases their destructive potential, yet their dynamics, particularly the factors contributing to their long runouts, remain poorly understood, preventing effective risk mitigation.

Given the challenges in monitoring PDCs in natural settings, analogue experiments provide a crucial avenue for investigation. This study employs a newly developed geophysical flow flume at the University of Edinburgh to simulate PDC dynamics using sand avalanches as analogues. By utilising high-speed imaging and Particle Image Velocimetry (PIV), we quantify granular temperature - a key factor influencing rheology and flow-substrate interactions. Despite advancements in PIV algorithms, applying this technique to granular flows remains non-trivial and specific PIV aspects need to be evaluated. To address these, we have employed Discrete Element Method (DEM) simulations to produce artificial footage with well-constrained properties, enabling precise calibration of our measurements.

Experiments on rough substrates suggest agitation concentration at flow base magnified at higher velocities. Subsequently, we investigate how granular flows destabilise erodible substrates, weakened through granular heating. Granular temperature is transferred from the flow to the substrate in a process which is not temporally uniform. When shear stresses reach sufficient levels, flows initiate the collapse of a critical volume of the underlying deposit, subsequently triggering a retrogressive dilation wave which induces complete failure of the pile. This process represents a potential PDC generation mechanism. Constraining the PDC dynamics explored by this study will aid refining prediction, hazard assessments and mitigation.

## 7.4 Turbulence modulation in clay-laden gravity currents

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*Robert Dorrell, Energy and Environment Institute, University of Hull, UK*

Subaqueous sediment gravity currents are volumetrically one of the most important sediment transport processes and frequently transport high volumes of cohesive sediment. They can be classified into different flow types, with turbidity currents (turbulent) and debris flows (turbulence-suppressed) as the two end members; transitional flows bridge the gap between turbidity currents and debris flows and exhibit transient turbulent behaviour. Depending on their boundary conditions, gravity currents, can evolve either way along the turbidity current and debris flow spectrum. However, despite commonly carrying high amounts of clay, relative to open-channel flows, our understanding of the turbulent dynamics and evolution of cohesive clay-laden sediment gravity currents remains limited. To address this shortcoming, new experiments using constant-flux flows in a submerged flume were conducted. Two different types of the gravity current evolution were identified, determined by the balance between turbulent and cohesive forces related to the formation of clay bonds. At low clay concentrations, entrainment of ambient water at the upper interface, plus the turbulence generated at the upper and lower boundaries that penetrated into the gravity current, prevented the formation of clay bonds. Consequently, such gravity currents evolved towards a more turbulent flow condition, i.e. turbidity current. At high clay concentrations, ambient water entrainment and turbulence generation were focused in the outer region allowing the formation of clay bonds in the inner region and hence the development of a plug flow in the inner region. Consequently, such gravity currents evolved towards a less turbulent flow condition, i.e. debris flow. Thus, in addition to the shifting balance between turbulent and cohesive forces, the history and evolution of a flow influence the formation of the type of gravity current.

## 7.5 Wave-Wake Interactions in Stratified Shelf Seas: Implications for Offshore Wind Infrastructure

Author: *Di Huang, Energy and Environment Institute, University of Hull, UK*
Contributors: *Charlie Lloyd, Energy and Environment Institute, University of Hull, UK*
*Robert Dorrell, Energy and Environment Institute, University of Hull, UK*
*Magda Carr, Newcastle University, UK*

These sets of studies investigate the complex interactions between offshore wind infrastructure and internal waves in stratified shelf seas, focusing on how these interactions influence wake dynamics and vertical mixing. Central to this research is the thermocline, a critical interface for global biogeochemical processes that support marine ecosystems and climate regulation. The research employs a globally unique stratified flow flume (SFF) at the University of Hull, designed to replicate the conditions of seasonally stratified seas by simulating the thermocline.

The experimental setup involves the creation of a stratified shear flow within a ducted system, utilising vertically stacked layers of hot and cold water, each controlled to specific flow rates. Internal waves are generated by 3D printed obstacles placed in the thermocline upstream of the test section, simulating perturbations caused by natural features such as ship keels or seabed topography. The first set of experiments focuses on characterising these internal wave-induced background flow processes.

Subsequent experiments introduce 3D printed models of fixed-bottom offshore wind structures downstream of the internal-wave-generating obstacles. The study explores wave-wake interactions across a broad range of flow conditions, varying both flow velocity and temperature gradients. In the final experimental phase, floating wind infrastructure is analysed, with the models fixed in the channel but allowed to pivot and vertically oscillate, mimicking real-world heaving motions.

To capture the dynamics of these interactions, state-of-the-art optical measurement techniques are employed, including Laser Induced Fluorescence (LIF) and tomographic Particle Tracking Velocimetry (PTV). These techniques enable high-resolution, simultaneous measurements of 3D velocity and density fields downstream of the wind structures. The experimental data, supported by expertise from academic and industry collaborators, could offer insights into the behaviour of stratified wakes and their potential ecological impacts with implications on shelf sea nutrient fluxes, primary productivity and carbon storage.

## 7.6 A numerical investigation of head on collisions between mode-1 and mode-2 Internal solitary waves

Author: *Seph Sanderson, Energy and Environment Institute, University of Hull, UK*
Contributors: *Magda Carr, Newcastle University, UK*
*Sam Hartharn-Evans, Northumbria University, UK*
*Marek Statsna, University of Waterloo, Canada*

Internal solitary waves are ubiquitous features in stratified waters across the world. Due to the stratified medium they propagate in, they exhibit modal behaviour, the first and second baroclinic modes (mode-1 and mode-2, respectively) are most commonly observed. Mode-2 ISWs are observed to have shorter length scales than their mode-1 counterparts, because of this, when mode-1 and mode-2 waves interact, the mode-1 wave acts as a modified background shear current destroying the mode-2 wave. Following unpublished experimental work by Carr et al., numerical simulations are performed to investigate head on collisions between mode-1 ISWs of depression and convex mode-2 waves to determine the fate of mode-2 waves after a collision. Numerical simulations are performed using the Spectral Parallel Incompressible Navier Stokes (SPINS) solver. It is concluded that under certain conditions, mode-2 waves can theoretically survive collisions with mode-1 waves and can retain their initial structure. It is found that the wave amplitude ratio is the key factor in deciding the outcome of collisions.

## 7.7 Sequence Stratigraphic Physical Modelling: Techniques for Analyzing Results

Author: *Keila de Holleben, Universidade Federal do Rio Grande do Sul, Brazil*
Contributors: *Lucas Xerxenevsky Bergue, Emanuelli Henke do Amaral, Vinícius Raphaelli Garcez dos Reis, Daniel Bayer da Silva, Carolina Holz Boffo, Rafael Manica*

Deposition in deep marine environments is influenced by various factors, including sea-level variation, river discharge, sediment concentration, and time. Combining these variables affects the hydrodynamic and sedimentation processes across the continental shelf, slope, and basin. Several studies focus on developing tools and methods for analysing data from physical simulations for use in data collection and sampling within the model. This study employs physical modelling approaches using 2D and 3D scale tanks. Representative river inflows were introduced with variations in flow rates, as well as in sand (coal) and mud (limestone powder) content, alongside fluctuations in sea level (water level in the tank) to simulate the oscillations of fourth- or fifth-order climate cycles. The experiments were divided into four phases: (1) construction of the initial stratigraphy; (2) lowering of the water level to simulate the Falling Stage System Tract (FSST); (3) maintenance of the low level to represent the Lowstand System Tract (LST); and (4) elevation of the water level to simulate the Transgressive System Tract (TST), concluding with high water levels representing the Highstand System Tract (HST). The evolution of the model after each phase was assessed by quantifying the increase in depositional thickness and the growth of eroded areas, with these dynamics of erosion and deposition linked to the position of the waterline. During the FSST phase, erosion on the shelf and slope increased sand transport to lower elevations, thickening the deposits on site. In the LST and TST phases, material accumulated on the shelf and slope as the waterline moved inland. A technique for sampling and preserving deposits using resin was developed. Furthermore, methods for analysing the temporal variation of fluvial parameters were established. The geometries and input parameters align with those of analogous experiments, and our advancements have significantly enhanced the analyses conducted in stratigraphic modelling.

# 8 Attendees who did not present

For the purpose of making it easier for people to find each other after the conference, we here list the people who attended the conference but did not present. The names of the presenters are already given against their presentation.

Attendees from the University of Hull:

- Rob Dorrell
- Rob Thomas
- Stuart McLelland
- Djemaliye Emir
- Nemi Walding
- Dave Petley
- Brian Houston

Attendees from other institutes:

- Amber Jones, University of Southampton, UK
- Joris Eggenhuisen, Utrecht University, Netherlands
- Karina Ruschel, Pontifícia Universidade Católica do Rio Grande do Sul, Brazil
- Malcolm Cook, Loughborough, UK
- Adam Crawford, Loughborough, UK

# 9 Contact Details

If you need to contact us during the conference then please do so using the contact details below:
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- Hajime Naruse: naruse@kueps.kyoto-u.ac.jp
- Robert Dorrell: r.dorrell@hull.ac.uk

# 10 Acknowledgements, Special Publication Details, and Future Plans

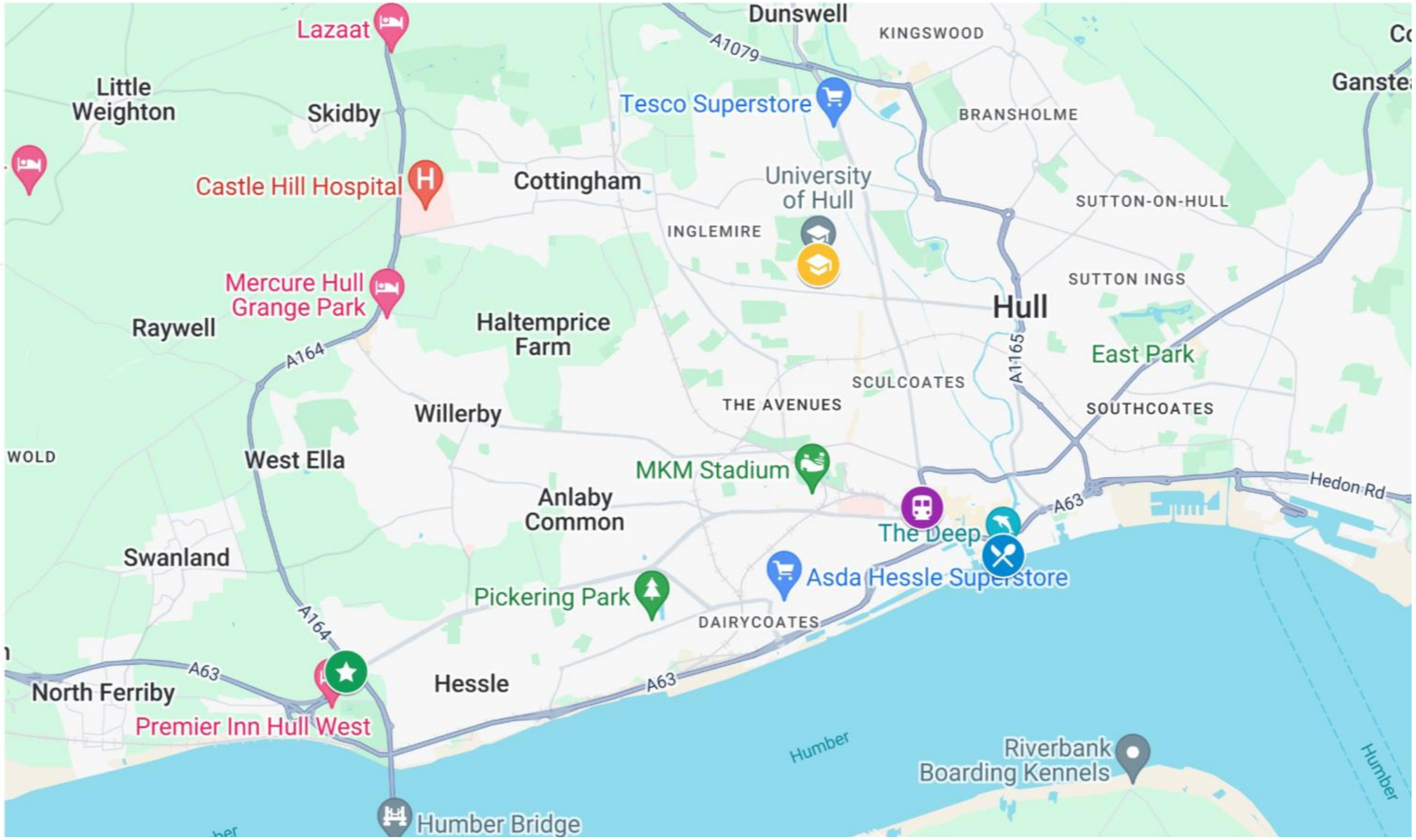
- The organisers would like to thank funders for enabling this conference.
    - Ed Skevington is funded by EPSRC, EP/X028577/1
    - Hajime Naruse is funded by the Sediment Dynamics Research Consortium
    - Robert Dorrell is funded by NERC NE/S014535/1
- This autumn there will be a call for a special publication on Particulate Gravity Currents, following on from this conference. The Special Publication will appear in the *Journal of Marine Science Engineering,* edited by the conference organisers. We would be delighted if attendees wished to submit their abstracts as papers to this publication. Open access and publication costs will follow standard JMSE policies. If attendees would like to contribute a paper we ask they contact the conference organisers by the end of September 2024.
- We are planning to host another Particulate Gravity Currents Conference in 2026 in Japan. We will contact you all when we have a date!

# 11 Maps

## Kingston Upon Hull, the City

Main Locations

- Paragon Railway Station
- University of Hull
- Aura Innovation Centre
- The Deep



## The City Centre, train station to conference dinner venue The Deep

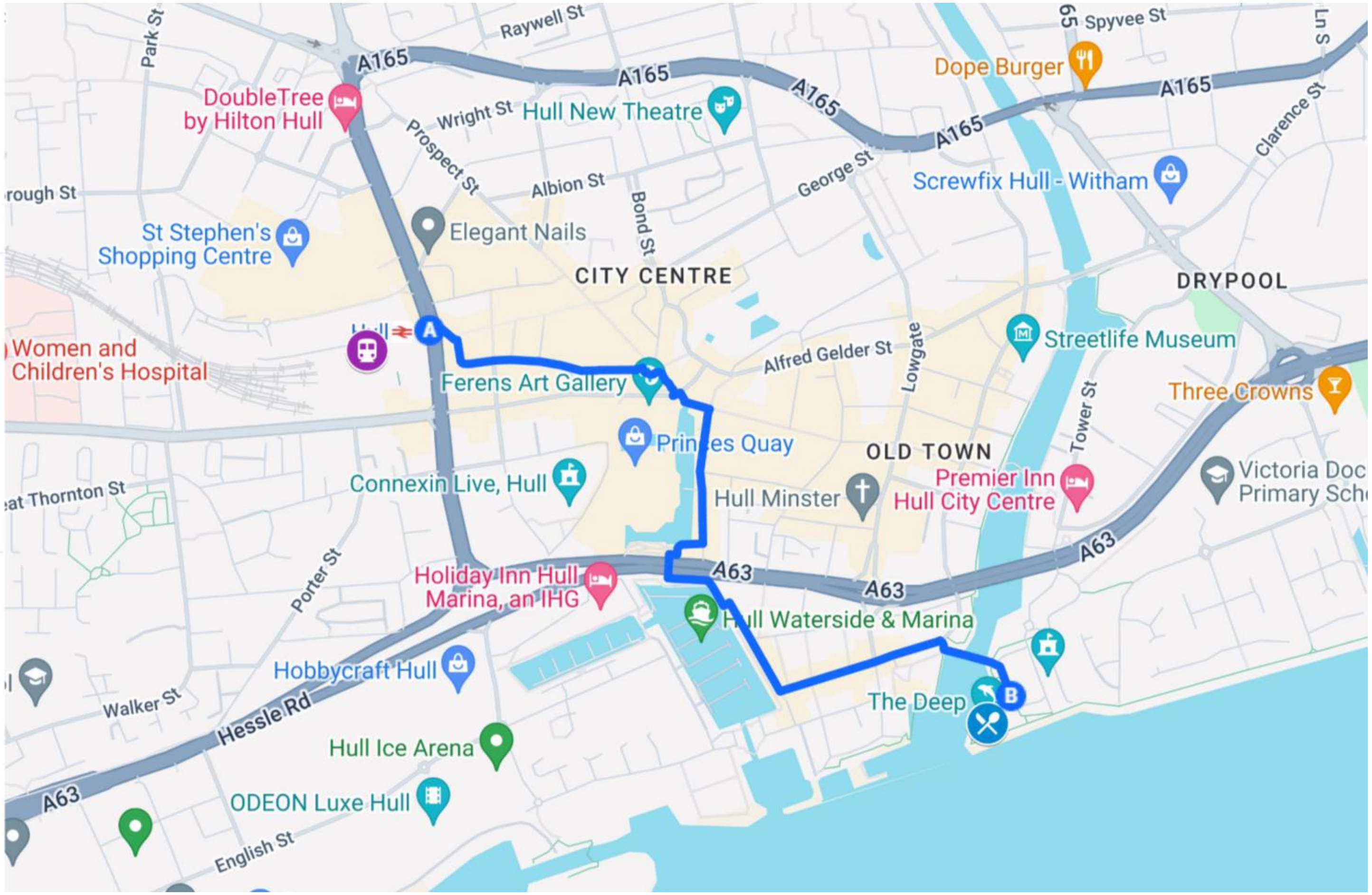
Main Locations

- Paragon Railway Station
- University of Hull
- Aura Innovation Centre
- The Deep

Directions

A
17 Jameson St, Hull HU1 3UF, UK

B
The Deep Business Centre, Hull HU1 4DP, UK



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# Aura Innovation Centre, conference venue and bus stops