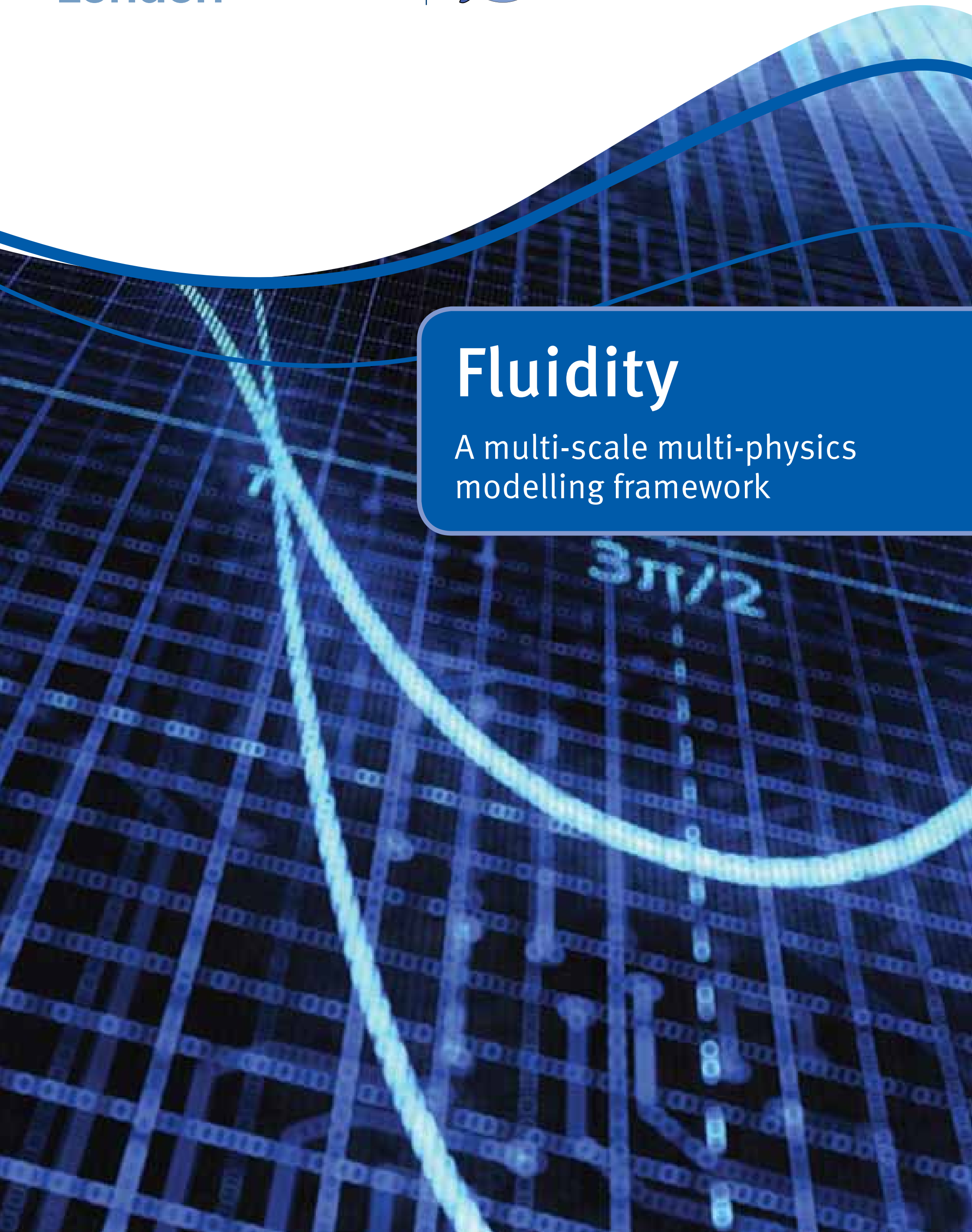
Imperial College London

fluidity

Fluidity

A multi-scale multi-physics modelling framework

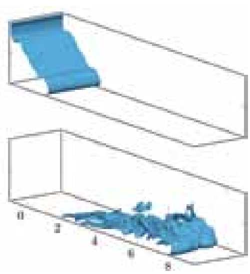


Fluidity is a user-friendly open source framework for the solution of partial differential equations using a variety of finite element and control volume discretisation methods. It has been developed for the solution of a wide range of industrial fluids problems as well as for geophysical-scale and buoyancy-driven flows. Fluidity's efficient multi-scale capabilities result from the use of advanced dynamic mesh adaptivity techniques, along with massively parallel computing.

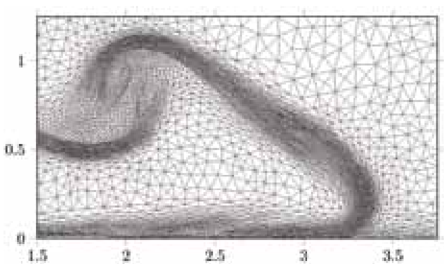
Key features

- Solvers for single, multi-material and multi-phase compressible/incompressible flows
- Range of stable and accurate finite element and control volume discretisation methods
- Methods specifically designed for buoyancy-driven and geophysical scale problems
- Multi-physics coupling of fluids with structures and radiation transport
- LES and RANS turbulence models
- World-leading anisotropic mesh adaptivity technology in 1, 2 and 3D
- Dynamically load-balanced parallelism for HPC, scalable to many 1000s of cores
- Graphical user interfaces and a user-friendly open source modelling pipeline
- Code robustness ensured through an extensive automated build testing framework

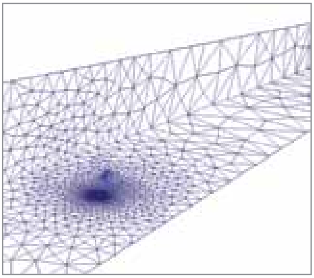
Applications



▲ Density isosurfaces from a direct numerical simulation (DNS) of a particle-laden density current in 3D using adaptive mesh technology.

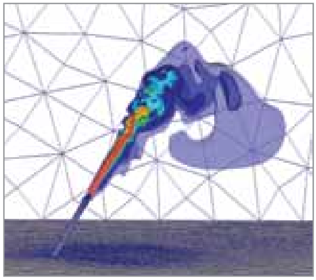


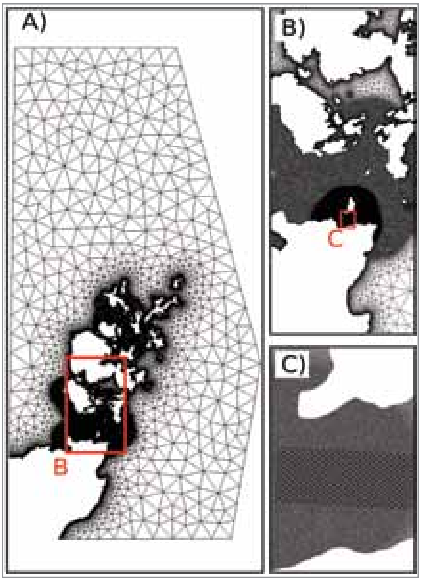
▲ Zoom of the adapted mesh efficiently resolving the head of the density current.

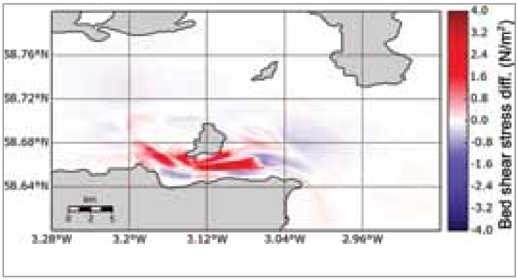


◄ A multi-scale simulation of a marine outfall discharging dense desalination plant effluent. The unstructured adapted mesh includes elements whose edge lengths vary by a factor of 10,000.

► Zoom of the outfall and near-field dynamics showing salinity modelled using LES techniques.







◄ An unstructured mesh of the region around the Orkney Islands for a simulation of a tidal turbine array. The multi-scale mesh resolution varies across four orders of magnitude: from 2m within the turbine array up to 20km in the far-field to efficiently represent the large-scale tidal dynamics.

▲ The impact to the ambient dynamics following the installation of a 400 MW turbine array.

Other industrial applications: flow through porous media and packed beds; mineral processing; flood defence design; nuclear safety (reactors and repositories); thermal hydraulics and multi-phase flows; fluid-structure interaction (e.g. turbines); turbulent flow in complex geometries.

Other geophysical applications: tsunamis; inundation; landslides; geodynamics; volcanic eruptions; desalination outfalls; atmospheric and oceanic pollution dispersal; coastal engineering; ocean biogeochemistry; palaeo-tides; buoyancy-driven flows under ice shelves; numerical wave tank and spectral wave modelling.

Vision

Our primary aim is the continual delivery of a reliable and easy-to-use problem-solving environment using advanced discretisation and meshing technology. We will expand our use of state-of-the-art adaptive mesh methods to facilitate the efficient multi-scale simulation of new industrial and geophysical problems. While our current methods scale in parallel to thousands of computing cores, we are preparing for future hardware advances by embracing the automatic code generation and performance portability offered by the Firedrake project. This has the added benefit of providing easy access to adjoint technology which we are beginning to use for important optimisation, data assimilation and uncertainty calculations.

Licence

Fluidity and all its third party dependencies are covered by industry-friendly open source licences such as LGPL, BSD and MIT.

Contact

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