Firedrake

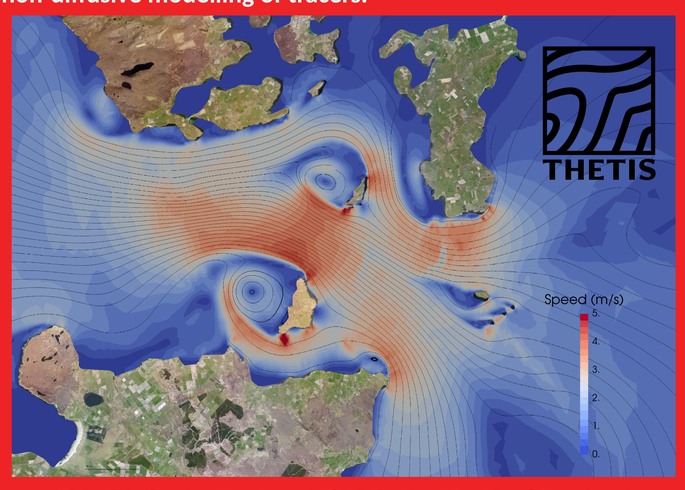
Firedrake applications

Imperial College London · University of Bath · University of Waterloo · OHSU Oregon Health & Science University · University of Leeds · University of Houston

Thetis - coastal flow solver

Tuomas Kärnä - Oregon Health and Science University
Stephan C. Kramer, Lawrence Mitchell, David A.Ham, Matthew D. Piggott - Imperial College London

Thetis is a coastal and estuarine modelling framework with applications in the simulation of 3D baroclinic river dynamics, and tidal energy projects. Efficient 3D layered meshes and a wide selection of finite element schemes enable the accurate, non-diffusive modelling of tracers.

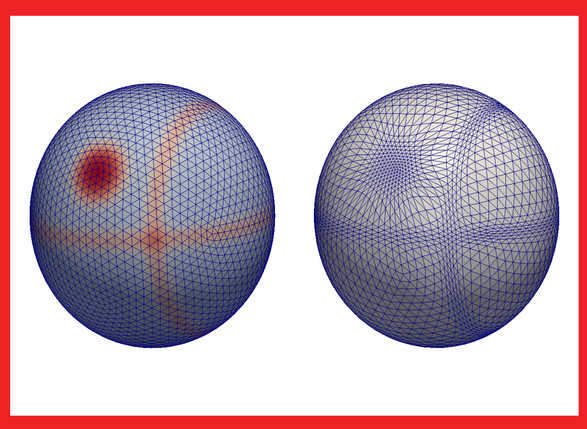


Ebb tide in the Pentland Firth in the North of Scotland, a region of high interest for tidal renewable energy.

r-adaptivity on the sphere

Andrew McRae and Chris Budd - University of Bath
Colin Cotter and Jemma Shipton - Imperial College London

We are interested in moving-mesh methods for atmospheric problems on the Earth. An essential operation is to adapt a mesh to a scalar monitor-function without changing the mesh connectivity; we do this by solving a Monge-Ampère-type equation on the sphere.

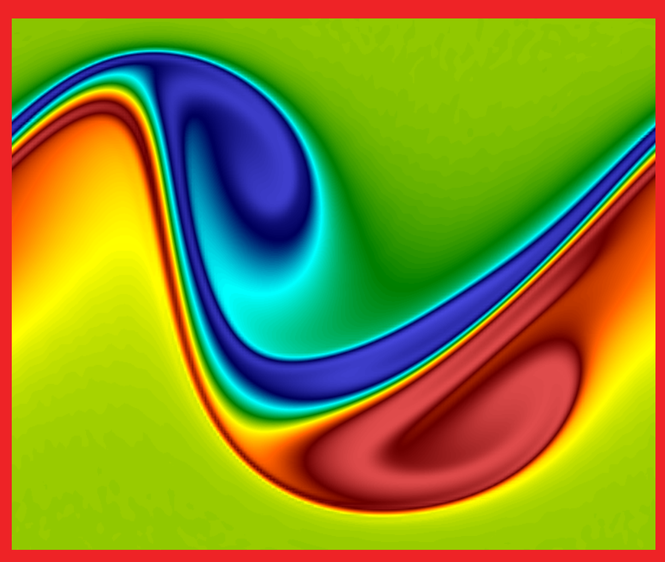


Monitor function and the resulting deformed mesh

The stability of jets and vortices

Francis Poulin - University of Waterloo

Developing software to study the stability characteristics of oceanic jets and vortices, such as the Gulf Stream and Meddies. The aim is to better understand the structures that they produce and how energy cascades across the different length scales.



2D jet becoming unstable in quasi-geostrophic flow

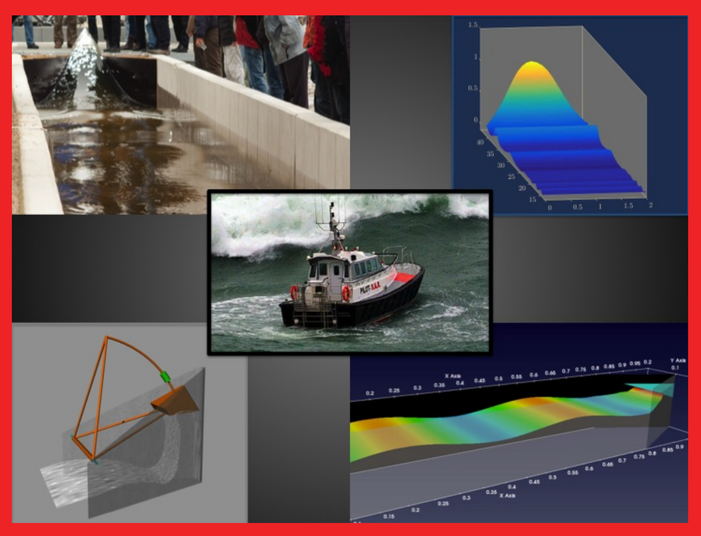
Water waves and structures

University of Leeds

Rogue wave impact on ships

Anna Kalogirou and Onno Bokhove

Study of the complex behaviour of water waves, including the generation of nonlinear rogue waves and their impact on ships.

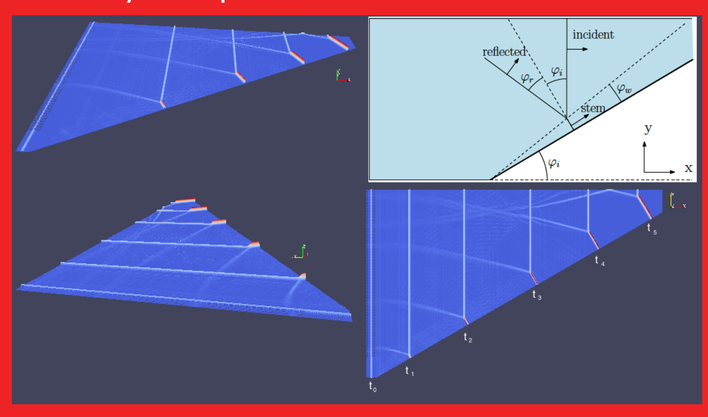


Soliton splash experiment and simulation (top), and motion of an amplified wave-energy buoy (bottom)

Freak wave modelling

Floriane Gidel and Onno Bokhove

Freak waves may be created when a solitary wave encounters an oblique wall. Firedrake is employed to simulate this using the Benney-Luke equations.

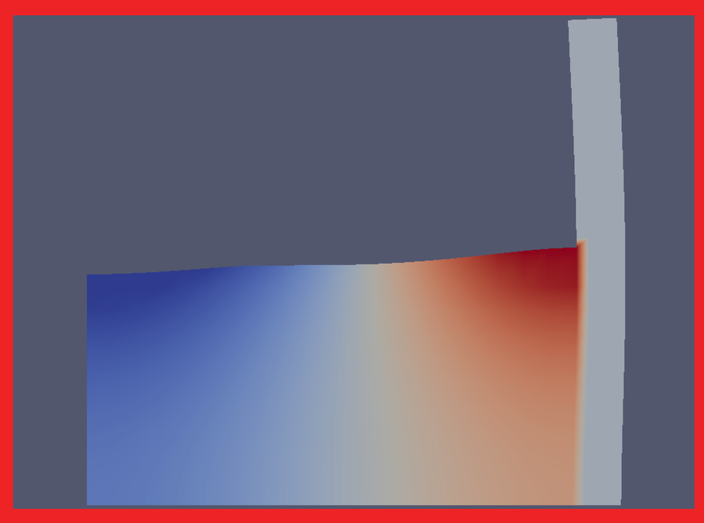


Schematic and Firedrake simulations of the time evolution of the incident, reflected and Mach stem waves

Fluid-structure interaction

Tomasz Salwa, Onno Bokhove, Mark Kelmanson

We develop a fluid-structure interaction model with application to water waves interacting with an offshore wind turbine.

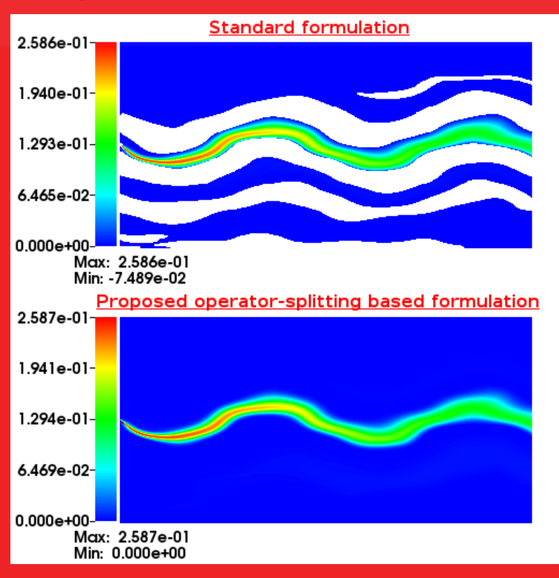


2D potential-flow fluid with a free surface (left) interacting with a monopile elastic solid (right).

Advective-diffusive-reactive geochemical systems

Justin Chang, Kalyana Nakshatrala, and Satish Karra - University of Houston

We model advection-diffusion-reaction by operator splitting. Convex optimization and variational inequality solvers on the individual operators ensure boundedness for critical tracers.



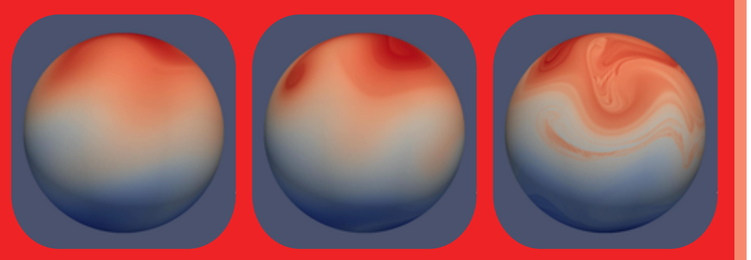
Formation of Calcite in a reaction tank where white regions denote negative free-ion concentrations.

Gusto - The Firedrake dynamical core project

Colin Cotter, David Ham, Lawrence Mitchell, Jemma Shipton, Hiroe Yamazaki - Imperial College London
Andrew McRae - University of Bath

We are using Firedrake to develop a testbed for a dynamical core (the fluids part) of a numerical weather prediction model, using compatible finite element methods. This is informing the development of a next generation dynamical core for the Met Office in the UK.

Firedrake's extruded meshes, non-affine geometry and support for a wide range of tensor product finite elements are key features.



The evolving potential vorticity field in an idealised atmosphere simulation.

firedrakeproject.org