Stuart Patching

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Education and Research

**Imperial College London (2017-present)**

PhD (2018-present)

*‘Eddy Parameterisations in Oceanic Primitive Equation Ocean Models.’*

EPSRC Centre for Doctoral Training in Mathematics of Planet Earth.

Supervisors: Prof. Darryl Holm, Dr Pavel Berloff, Dr Igor Shevchenko.

Project Summary: Western boundary currents such as the Gulf Stream have significant consequences for the Earth’s climate. However, modelling such features is a highly non-trivial problem, owing to their non-linear and turbulent nature. In particular, it is believed that mesoscale eddy effects are responsible for maintaining the eastward jet extensions of western boundary currents, although the mechanism responsible for this is not well understood. Moreover, running simulations that resolve mesoscale eddies is not practical for timescales relevant for climate studies. Therefore, it is necessary to introduce a parameterisation of the eddy backscatter effect so that it may be represented in coarser-grid simulations. My project focuses on three such parameterisation methods which have been demonstrated successfully in simple quasi-geostrophic models; however, I would like to implement them into more realistic primitive equation or Boussinesq models.

Running fine grid global ocean circulation models on climate timescales is too computationally expensive for practical applications; however, small scale eddy effects have important consequences, even on large spatial scales. Therefore, in order to capture the effects of small-scale eddies in coarser grid simulations, it is necessary to develop parameterisations of the eddy phenomena in order to capture their effects. This involves modifying a numerical scheme in some appropriately chosen way; my aim is to implement such parameterisations into the global ocean circulation models FESOM2.0 and MITgcm, which I am running on the Imperial College high-performance computing cluster.

MRes (2017-2018, Pass with Distinction)

*‘Analysis of Stochastic Slow-Fast Systems.’*

EPSRC Centre for Doctoral Training in Mathematics of Planet Earth.

Supervisors: Prof Xue-Mei Li, Prof. Darryl Holm, Prof. Dan Crisan.

Project Summary: In 1986 Edward Lorenz proposed a system of ODEs derived from the rotating shallow water equations which he studied as a toy model for the gravity wave-Rossby wave interaction in atmospheric or oceanic dynamics. In my project we considered a version of these equations modified to include stochasticity and made use of their Hamiltonian structure to apply techniques from stochastic averaging.

Courses taken: PDEs (97.5%), Data and Uncertainty (100%), Numerical Methods (91%), Dynamical Systems (100%), Introduction to Geophysical Fluid Dynamics (100%).

**Selwyn College, University of Cambridge (2011-2015)**

MMath (2014-2015, Pass with Distinction)

Courses taken: Quantum Field Theory, Symmetry and Particle Physics, General Relativity, Black Holes, Differential Geometry in Physics.

BA in Mathematics (2011-2014, First class honours)

Courses taken include: Classical Mechanics, Quantum Mechanics, Fluid Dynamics, Electrodynamics, Complex Analysis, Real Analysis, Topology, Group Theory, Number Theory, Linear Algebra, Computational Projects.

Teaching

**Multivariate Calculus, Graduate Teaching Assistant (October-December 2018)**

Second year Mathematics undergraduate course at Imperial College. One term, including demonstrating in tutorials and exam marking.

**PDEs, Graduate Teaching Assistant (November-December 2018)**

MRes course for Mathematics of Planet Earth CDT at Imperial College. Demonstrating in three tutorials. Focus on geometric approach to Fluid Dynamics via variational principles.

Technical Skills

**Fluid Dynamics**

* Second-year Fluids course at University of Cambridge, 53/60 marks scored in exam.
* Masters-level course Introduction to Geophysical Fluid Dynamics at Imperial College. 100% in exam.
* PDEs MRes course for MPE-CDT was largely concerned with Rotating Shallow Water equations. 97.5% in exam. I am now Graduate Teaching Assistant for this course.
* MRes project required strong knowledge of fluid dynamics, particularly the rotating shallow water equations and their relation to the Lorenz ‘86 model.

**Programming**

* C used for undergraduate computational projects.
* C++ learnt during internship at Centre for Scientific Computing, University of Cambridge (2016).
* Python used for Numerical Methods coursework, MRes course for MPE-CDT.
* MATLAB used regularly during MRes project to simulate the equations under consideration.
* Fortran will be featured heavily in my PhD project.
* Current PhD project uses Imperial College high performance computing cluster.
* LaTeX used proficiently.

**Numerical Methods**

* My current PhD project concerns the global circulation ocean model ‘FESOM2.0’ based on Finite Volume Method used in conjunction with Arbitrary Lagrangian-Eulerian (ALE) coordinates.
* Finite difference methods for advection equation and conjugate gradient algorithm studied in Numerical Methods MRes course for MPE-CDT. 91% in exam.
* Symplectic integration methods for stochastic differential equations implemented during MRes project.

Other Experience

**Volunteer, Raleigh Nicaragua (March-June 2017)**

* Raised over £1300 prior to participating in volunteering programme.
* Spent three months in a rural community in Nicaragua.
* Organized and took part in many educational and constructional activities, often conducted in Spanish.

**Teacher of English as a Foreign Language, Madrid (January-June 2016)**

* Gave one-to-one lessons in a language academy.
* Worked as assistant teacher in a bilingual secondary school

**Internship, Centre for Scientific Computing, University of Cambridge (October-November 2016)**

* Spent two months in Cambridge to attend lectures and learn programming.
* Gained knowledge of C, C++, Python and MATLAB during this time.
* Studied a course on the basics of Machine Learning.

**Summer Research Project, Department of Chemistry, University of Cambridge (July-August 2015)**

* Two-month project in Theoretical Chemistry group, studying Quantum Transition State Theory.

**Summer Research Project, Mathematical Institute, University of Oxford (July-August 2014)**

* Two-month project at Oxford Non-Linear PDEs group.
* Successfully proved a result concerning the geometry of materials with a certain crystalline structure.