

# Liam Brannigan

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My work focuses on developing simple models to describe complex phenomena, using methods that range from machine learning to mathematical solutions of partial differential equations. I enjoy telling the stories represented by these models using state-of-the-art visualisation techniques. My experience encompasses both financial consulting and research in physical oceanography.

## Data Analysis Experience

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- Data gathering: Identifying data sources and building collaborations to access data from closed sources. Compressing and transferring multi-terabyte datasets.
- Data cleaning: Creating suitable file architecture. Incorporating metadata and handling missing values. Developing reproducible workflow in python for processing raw data. Converting from .csv to binary formats where necessary.
- Data exploration: Developing interactive visualisation tools to explore parameter space more quickly. Visualising data as time series, scatter plots or histograms. Calculating descriptive statistics such as means, variances or correlations.
- Model development: Selecting the appropriate type of model to use e.g. dynamical system, signal processing or statistical model. Developing simple prototype models. Understanding strengths and weaknesses of the model. Feature engineering to improve model performance.
- Model evaluation: Identifying suitable metrics for model evaluation. Using cross-validation methods to assess out-of-sample performance. Developing tools to allow visual assessment of models.
- Communication: Preparing static or interactive (html) slideshows to display results. Writing up results as research papers or blog posts. Presenting results in seminars and at conferences.

## Professional Experience

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- 2016 – Jan 2018 **Post-doctoral fellow**, Stockholm University, Sweden
- 2015 – 2016 **Post-doctoral fellow**, University of Southampton & University of Oxford, UK
- 2006 – 2010 **Investment consultant**, Lane Clark & Peacock (LCP), London, UK

## Education

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- 2011 – 2015 **University of Oxford**, PhD Ocean Physics
- 2010 – 2011 **Bangor University**, MSc Applied Physical Oceanography, Distinction
- 2007 – 2009 Passed all three **Chartered Financial Analyst Institute** exams
- 2002 – 2006 **Edinburgh University**, MA Mathematics, First Class Honours

## Awards in Education

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- 2016-2018 Wenner-Grenn Research Fellowship, Stockholm University
- 2013 Werrett Prize for 2nd Year PhD report, University of Oxford
- 2012 Johnson Prize for 1st Year PhD report, University of Oxford
- 2005-2006 Horslie-Hill Scott Prize for performance in exams, University of Edinburgh

## Teaching

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- “Introduction to programming with Python”: One week course for new graduate students in environmental research at the University of Oxford in October 2017, co-developed with a teaching-focussed academic. Focus on grasping programming concepts and applications with practical examples and real datasets and an emphasis on using the Pandas package in Python.
- “[Better analysis with python](#)”: Three-hour interactive workshop in Stockholm University in November 2017 using Jupyter notebooks. Attendees learn how many common analysis problems in climate science can be solved using python packages. Discussed time series analysis with Pandas, just-in-time compilation with Numba, parallel analysis with Dask and climate model analysis with Xarray. Available online as an open educational resource.
- “Introduction to Bayesian statistics”: Three-hour interactive workshop in Stockholm and Bergen in January/February 2018. Workshop will cover Bayesian probability, fitting statistical models and linear regression including how Bayesian methods relate to other forms of machine learning.
- “Turbulence in the oceanic boundary layer”: Two-hour lecture in Stockholm presented using a Flask-based mini web framework to allow interactivity during the lecture.
- “Fluids, flows and complexity”: Tutored in 3<sup>rd</sup> year Oxford physics course on fluid mechanics and dynamical systems (2012 & 2014). Emphasis on interpreting solutions to equations.

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## Professional Skills

Presentations:	Extensive experience presenting complex ideas to diverse audiences. I have often been told by non-specialist attendees that my presentations are particularly clear.
Writing:	Experience producing focused reports for clients and scientific audiences using both Microsoft Office and LaTeX.
Financial:	Carried out research into fixed income investment managers to assess suitability for pension fund investments. Explained developments in fixed income and derivative markets to colleagues and clients. Advised on long-term investment strategy for pension schemes.
Workflow:	Worked routinely to short deadlines in finance as part of adaptable client teams. Managed long-term solo projects in research. Pioneered reproducible workflow in oceanography using github repositories. Established a monthly meeting in Stockholm for researchers to get feedback on their work-in-progress.
Client relations:	Presented to clients and advised on issues in trustee board meetings. Prepared billing statements and discussed fee proposals for projects with clients. Arranged transfers of client assets between investment managers.

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## Data projects

- MSc. project on wind-driven turbulence in Drake Passage:** My data consisted of ocean current observations made with sonar, synthesised from hundreds of separate crossings of Drake Passage. After replacing missing data with interpolated values where possible, I applied Fourier and wavelet transforms to analyse the frequency content of the data. I adapted a simple dynamical model from the shallow ocean to apply to deep ocean conditions, and published my results in a leading oceanography journal.
- PhD. project on turbulence in the ocean's near-surface layer:** I developed my research questions from a critical reading of the literature and decided to test hypotheses as to the causes of turbulence. I derived initial and boundary conditions for a numerical ocean simulation and ran the simulations in parallel. I developed a mathematical linear stability analysis to identify turbulent processes and created diagnostics to test my hypotheses. My results are published across three articles in leading oceanography journals and have been presented internationally.
- Postdoc project on melting around Antarctic ice shelves:** I was invited to join an existing project that had made ship-based observations from around melting Antarctic ice shelves. I developed a set of numerical simulations to complement the observations. I advised on the physical processes driving the observations and co-authored a paper in Nature.
- Postdoc project on Arctic vortices:** I identified a process that could help to improve our understanding of vortices in the Arctic Ocean and carried out numerical simulations to test this idea. I analysed the output of the simulations using K-Means analysis to track vortices. I derived a mathematical model with a collaborator that captured the essential results of the numerical simulations. I created an animation package using Matplotlib in Python to visualise the results. I wrote-up the results as a paper in a leading oceanography journal.
- Postdoc project on Arctic predictability:** I wanted to understand whether ocean properties observed near Ireland can be used to predict events in the Arctic Ocean in subsequent years. I built a collaboration with researchers in the UK who had a suitable dataset. I extracted features from the dataset to be used as outcome and predictor variables. I performed deterministic correlation analysis to drive feature engineering. I carried out Bayesian correlation analysis to understand the uncertainty in these estimates. I developed Bayesian linear regression models to predict outcomes in the Arctic. I carried out model comparison by varying hyperparameters. I also compared the results with other deterministic regression techniques such as elastic nets and lasso regression.

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## Communication

Outreach:	Talks on oceanographic research and scientific careers at science fairs, departmental open days and town centre science events.
Blogging:	Focus on data analysis and visualisation methods. My blog posts have covered Bayesian <a href="#">model fitting</a> , <a href="#">correlation</a> and <a href="#">just-in-time compilation</a> . I make posts available as interactive Jupyter notebooks from my github site. These posts also demonstrate interactive visualisation approaches using the Bokeh and Holoviews plotting libraries.

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## Technical

Analysis:	Extensive experience using packages such as NumPy, Pandas, Dask and Numba for data analysis. Also have long experience using Matlab for similar tasks and basic
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experience using R.

Visualisation: Matplotlib, Seaborn, Bokeh and Holoviews for visualisation in Python.

Machine learning: Scikit-learn for regression. K-Means for cluster identification. Basic familiarity using TensorFlow and Keras for deep learning.

Bayesian analysis: Using PyMC3 and Stan packages for Bayesian analysis. Have used both R and Python interfaces for Stan package.

Lower-level: Ran numerical simulations in Fortran using pre-existing model code. Made minor modifications to code to include additional diagnostics. Basic familiarity with C++.

Operating systems: Extensive experience using Linux and Mac operating systems. Using Bash scripts to handle files. Version control with git to manage analysis projects and my website.

## Mentoring

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Doctoral	Xiaolong Yu (U. Southampton, 2014 – 2017) I provided guidance on research areas, discussed technical concepts and feedback on draft papers.
Professional	Mentoring new graduates at LCP (2008-2010) I supervised their work, provided feedback on draft reports and demonstrated use of software such as Bloomberg terminals.

## Research Grants

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2016 - 2018	Wenner-Grenn Postdoctoral Fellowship (PI – 600,000 SEK)
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## Selected Publications

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**Brannigan L et al.** (2017) Generation of sub-surface anticyclones at Arctic surface fronts due to a surface stress, *Journal of Physical Oceanography*

Naveira Garabato AC *et al* (2017) Vigorous lateral export of the meltwater outflow from a thinning Antarctic ice shelf. *Nature* doi:10.1038/nature20825

**Brannigan L** (2016) Intense submesoscale upwelling in anticyclonic eddies. *Geophysical Research Letters* doi:10.1002/2016GL067926

Buckingham CE *et al* (2016) Seasonality of submesoscale flows in the ocean surface boundary layer. *Geophysical Research Letters* doi:10.1002/2016GL068009

**Brannigan L et al.** (2015) The seasonal cycle of submesoscale flows. *Ocean Modelling* doi:10.1016/j.o-ceomod.2015.05.002

**Brannigan, L, et al.** (2013) Shear at the base of the oceanic mixed layer generated by wind shear alignment. *Journal of Physical Oceanography* doi:10.1175/JPO-D-12-0104.1

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