25 - 29 November 2019

Uncertainty Quantification Workshop

Mathematical Sciences Institute, The Australian National University

MSI Special Year in 2019

Program & Title and Abstract booklet

Conference speakers

- Karen Willcox, The University of Texas at Austin
- Dongbin Xiu, Ohio State University
- Aurore Delaigle, Melbourne University
- Michael Eldred, Sandia National Laboratories
- Claudia Schillings, University Mannheim

Organising committee

- Stephen Roberts, Australian National University
- John Jakeman, Sandia National Laboratories
- Tiangang Cui, Monash University
- Quoc Le Gia, University of New South Wales
- Katharine Turner, Australian National University

For more information go to: https://maths.anu.edu.au/news-events/events/uncertainty-quantification-workshop

Australian National University

AMSI Australian Mathematical Sciences Institute

Aust MS Australian Mathematical Society Inc.

	Monday 25/11/2019	Tuesday 26/11/2019	Wednesday 27/11/2019	Thursday 28/11/2019	Friday 29/11/2019
9:30	**Registration**	**Keynote Lecture:** Helmut Harbrecht	**Keynote Lecture:** Frances Kuo	**Keynote Lecture:** Aurore Delaigle	**Keynote Lecture:** Karen Willcox
10:15	**Welcome**				
10:30	**Keynote Lecture:** John Jakeman	**Morning tea**	**Morning tea**	**Morning tea**	**Morning tea**
11:00		**Invited speaker:** Ivan Graham	**Invited speaker:** Joseph Guillaume	**Invited speaker:** Lindon Roberts	**Invited speaker:** Jing Yang
11:30	Collaboration/ Breakouts	**Invited speaker:** Ian Sloan	**Invited speaker:** Hanna Kurniawati	**Invited speaker:** Quoc Thong Le Gia	**Invited speaker:** Rob Williamson
12:30	**Lunch (Provided)**	**Lunch**	**Lunch**	**Lunch**	**Lunch**
13:30	Collaboration/ Breakouts	Collaboration/ Breakouts	Collaboration/ Breakouts	Collaboration/ Breakouts	Collaboration/ Breakouts
14:30	**Keynote Lecture:** Tiangang Cui				
15:30	**Invited speaker:** Vesa Kaarnioja	**Invited speaker:** Scott Lindstrom	**Invited speaker:** Barry Croke	**MSI Afternoon tea**	
16:00	**Invited speaker:** Tony Jakeman	**Invited speaker:** Michael Rehme	**Invited speaker:** Bill Lozanovski	**MSI Event/ Mahler Lecture:** Dr Holly Krieger	**Closing remarks**
16:30					

TRANSPORT - GETTING AROUND

There are many ways to get around Canberra. Below is some useful information about bus and taxi transport around the ANU, the airport and surrounding areas.

Taxi

To book a taxi from ANU to the airport request to be collected from the Ian Ross Building or the ANU gym on North road. A taxi to the airport usually costs around $40 and travel time is approximately 15 minutes. Pricing and time may vary depending on traffic.

- Canberra Elite Taxis: 13 22 27
- ACT Cabs: 6280 0077
- Silver Service Canberra:133 100

Buses

Canberra buses are a cheap and easy way of getting around town once you're here.

To view the bus timetable, go to: https://www.transport.act.gov.au/getting-around

Canberra Light Rail

If you are staying in the North of Canberra, the Light Rail would be a suitable option for you. The train runs from Gungahlin marketplace to the Canberra city centre.

To travel just use your MyWay card or purchase a ticket from the vending machines located at all the stops and bus interchanges. You can purchase a single trip ticket which includes a free 90 minute transfer period.

For more information on the light rail go to:
https://www.transport.act.gov.au/about-us/public-transport-options/light-rail

WIFI ACCESS

Conference wifi information is listed below. If you have any issues logging into ANU Access please contact Admin.research.msi@anu.edu.au

USERNAME: UQworkshop
PASSWORD: Specialyear2019

ANU Access

ANU Access is only available to staff and affiliates, and to connect you will require an ANU ID.

To connect to ANU Access:

1. Make sure the wireless network port is active.
2. Select ANU Access from the list of available wireless networks.
3. Enter your ANU ID and password, and press login.

Once connected, it is not necessary to log out of ANU Access-you will be automatically logged out after a certain period of inactivity. However, if you have javascript enabled on your browser, a logout window will pop-up.

It is strongly recommend that you enable your operating system's firewall, use up-to-date anti-virus software and read the Wireless Security Recommendations.

Eduroam

Eduroam is a wireless network that allows visiting students, staff and academics to connect to and access a University's wireless network using their home university login. Eduroam is available on a range of operating systems including iPhone/iPad, Macintosh, Windows XP, Windows Vista, Windows 7, Blackberry, Android and Linux, and is available wherever you find ANU Secure. Usually the participating institution will allow users to open a Virtual Private Network (VPN) connection to your home institution.

All ANU staff and students can be eduroam users when at a participating national and international institutions, but should not attempt to log on to the eduroam network when at ANU.

OUT AND ABOUT IN CANBERRA

CANBERRA MARKETS

Canberra Hospital Markets
Cnr Yamba & Hindmarsh Drives, Woden
Phone: 6254 6140
5th Sunday each month, 9am – 2pm. Home-made crafts and plants.
Money raised grants wishes to cancer patients.

Gorman House Markets
Cnr Ainslie Ave & Hesse St, Canberra City
Phone: 6247 3202
Saturday, 10am – 4pm
New & used clothes, books, vegies, craft, furniture,
multicultural food, live music.

Hall Markets
Hall Showground (near Victoria St)
Phone: 6260 5555
1st Sunday each month, 10am – 3pm, gold coin entry
Home produce, crafts, food, live music, kids activities and more.

Old Bus Depot Markets
Wentworth Avenue Kingston
Phone: 6292 8391
www.obdm.com.au
Sunday, 10am – 4pm
Quality art & craft, clothing, jewellery, plants, home wares,
produce, food, etc.

Belconnen Fresh Food Markets
Lathlain St, Belconnen
Phone: 6251 1680
Wednesday – Sunday, 8am – 6pm
Some stores are open 7 days

Food Co-Op
Phone: 6257 1186
Open Tues & Thurs 10am – 7pm
Wed, Fri & Sat 10am – 4pm
www.anu.foodco-op.com

Canberra Region Farmers Market
Exhibition Park (EPIC), Northbourne Ave
Phone: 0419 626 234
Saturday, 7:30am – 11:30am

Fyshwick Fresh Food Markets
Cnr Mildura & Dalby St, Fyshwick
Phone: 6295 0606

PLACES OF INTEREST

Bush Walking in the Capital
Canberra has great bush walking trails for all levels.
For more information:
www.anumc.edu.au

The National Portrait Gallery
(2 locations)
1.Commonwealth Place, Parkes
2.Old Parliament House, Parkes
Phone: 6270 8236
www.portrait.gov.au

Australian National Botanic Gardens
Clunies Ross St, Acton
Phone: 6250 9540
www.anbg.gov.au

Black Mountain
Clunies Ross St, Acton
Phone: 6207 2500
National Gallery of Australia
Parkes Place, Parkes, Phone: 6240 6502
Free entry to the permanent collection and varying charges for other exhibitions.
www.nga.gov.au

The National Library
Parkes Pl, Parkes, Phone: 6262 1111
Telstra Tower
Black Mountain Drive, Acton
Phone: 6219 6111
www.nla.gov.au

Cockington Green Gardens
11 Gold Creek Road, Nicholls ACT 2913
(02) 6230 2273
http://www.cockingtongreen.com.au

National Zoo and aquarium
999 Lady Denman Dr, Weston Creek ACT 2611
(02) 6287 8400
http://www.nationalzoo.com.au

Canberra Glassworks
11 Wentworth Avenue, Kingston Foreshore
Kingston, Australian Capital Territory
Australia, 2604
Phone: 02 6260 7005
www.canberraglassworks.com

The National Museum of Australia
Lawson Cres, Acton Peninsula, Acton.
Phone: 6208 5000 or 1800 026 132
Free entry to the standard museum and varying charges for temporary exhibitions.
www.nma.gov.au

Old Parliament House
King George Tce, Parkes, Phone: 6270 8222
Entry: adult $2, Con $1, Family $5
www.oph.gov.au

The Australian War Memorial and Anzac Parade
Anzac Parade, Phone: 6243 4211
www.awm.gov.au

Lake Burley Griffin
A short walk or cycle from the ANU or civic. The great thing about the Lake is that you can access it from a variety of different locations. (Parking – turn off Commonwealth Avenue)

Mt Ainslie & Remembrance Nature Park
Slopes of Mt Ainslie
Phone: 6207 2113

National Film and Sound Archive
McCoy Circuit, Acton
Phone: 6248 2000
www.nfsa.gov.au

The National Arboretum Canberra
Forest Drive (off Tuggeranong Parkway),
Acton, Australian Capital Territory, Australia, 2611
www.nationalarboretum.act.gov.au/

To find out more fun things to do in Canberra go to: http://www.visitcanberra.com.au

Title and Abstracts

Uncertainty Quantification Workshop

***

Challenges for uncertainty quantification in hydrological modelling

Barry Croke
Australian National University

The goal of hydrological modelling is several-fold, from gaining understanding of processes, to managing water resources and designing infrastructure to handle extremes. In all cases, what is needed is models that can capture the behaviour of catchments, based on available observations. Given the large uncertainties in observed quantities (e.g. streamflow, water quality, rainfall, evaporation rates), handling uncertainties has been something that has been a concern for hydrologists. Traditionally, model residuals have been used as a measure of the model uncertainties, with uncertainty in data used ignored. The problem with this is that this biases towards more complex models, and ignores the increase in uncertainty associated with increasing number of parameters.

While there has been considerable work done on quantifying uncertainty, this is still problematic for several reasons. Firstly, the results are model specific, so using techniques like Bayesian inference to estimate the uncertainties in the inputs is problematic (need a good idea of the uncertainty before you start). Secondly, the computational time involved limits application in many situations. Finally, in order to predict flows at ungauged or poorly gauges sites, parameter values need to be related to catchment attributes, which is difficult for non-linear models with parameters that interact and have a large degree of uncertainty.

From a simplistic viewpoint, what is needed is a more systematic treatment of uncertainty from the start. This means determining uncertainty in the interpolated areal rainfall, and consideration of the impact of the information that is lost in sampling this (e.g. if using daily data, then almost all the information on rainfall intensity is lost). Similarly, the limitations in the measurements of potential evapotranspiration need careful consideration, as does the uncertainty in the rating curve used to convert the observed stream level into a discharge rate. Carrying out such investigations is time consuming and therefore by and large, this is ignored. Converting this to just looking at the impact on the model outputs would be more efficient, and tools for this have been developed. The issue here is that the results are model specific, particularly in terms of the estimated uncertainties in the model inputs.

In summary, the hydrological community needs a lot of assistance in terms of Uncertainty Quantification!

***

Classifying and clustering functional data using projections

Aurore Delaigle
Melbourne University

We show that, in the functional data context, by appropriately exploiting the functional nature of the data, it is possible to classify and cluster the observations asymptotically perfectly. We demonstrate that this level of performance can often be achieved as the data are projected on a carefully chosen finite dimensional space.

In the clustering case, we propose an iterative algorithm to choose the projection functions in a way that optimises clustering performance, where, to avoid peculiar solutions, we use a weighted least-squares criterion. We apply our iterative clustering procedure on simulated and real data.

***

Uncertainty quantification for the Helmholtz equation

Ivan Graham
University of Bath

Joint with Owen Pembery and Euan Spence

In this talk I'll discuss the forward problem of uncertainty quantification for problems governed by the frequency domain wave (Helmholtz) equation, where the coefficients of the PDE (e.g. wave speed and material density) are random fields. Via parametrization, the random PDE problem can be written as a parametrized family of deterministic PDEs with (possibly high-dimensional) parameter, and one wants to compute expected values or other moments of quantities derived from the PDE solutions. Such problems can in principle be solved by sampling the PDE (many times over at 'good' sample points) and then averaging.

Recent years have seen the emergence of many successful fast algorithms for UQ for some classes of PDEs, particularly the diffusion equation. These depend crucially on the existence of fast modern multilevel solvers for each sample of the equation. Solvers for samples of the Helmholtz equation are much more problematic. However we show in the Helmholtz case that if the system matrix corresponding to a given parameter choice is LU factorized, then the LU factors can be used as a preconditioner for other 'nearby' problems (in parameter space). Thus most samples can be computed by iteration, and the exact LU factorization is needed for only a few samples.

We give a theoretical basis for this observation and provide numerical illustration of a random Helmholtz problem sampled by a Quasi-Monte Carlo method where about 10^5 samples are computed using about 10^3 exact factorizations. The method also has the property that the number of iterations is observed to be growing extremely slowly as the frequency of the wave equation increases.

***

Interactive exploration of input space as an alternative to “Estimate and Propagate”

Joseph H.A. Guillaume
Australian National University

Hydrological, water quality, and water management modelling is in the middle of a paradigm shift in how it addresses parameter estimation and uncertainty quantification. Manual and deterministic parameter estimation are increasingly being phased out, but there are several competing alternatives. Due to difficulties in specifying credible likelihood functions, initial debate contrasted formal statistical methods with informal objective functions, limits of acceptability/set membership estimation, and Approximate Bayesian Computation. Since then, information theoretic approaches have been proposed that reject the use of a likelihood function in favour of comparing the quantity and quality of information in competing stochastic models. All of these still subscribe to an “estimate and propagate” paradigm, in which parameter uncertainty is explicitly characterised.

One more contender has emerged from scenario literature as a result of the challenges posed by climate change. In the absence of reliable priors or data for making predictions, “hypothesis testing” or “bottom-up” approaches aim to identify plausible scenarios that produce pre-determined model results, e.g. vulnerability analyses identifying parameter or input values leading to undesirable outcomes. While existing applications were intended to address narrowly defined problems, it is now clear that they belong to a broad class of methods that allow conclusions to be drawn by searching for critical scenarios through an implicitly defined input space rather than explicitly characterising uncertainty in that space. Robust optimisation is another special case in this class of methods.

These methods have potential to decrease computational cost by only producing the information that is directly used by decision makers. In the process, experts (e.g. hydrologists) can react to the scenarios produced by these methods and use their tacit knowledge to further constrain uncertainty interactively within the uncertainty quantification process itself. There are substantial opportunities for exploring the scope and potential of these methods, as well as in development and application of tailored optimisation approaches to enable efficient exploration of input space on an interactive timescale.

***

A spectral method for the stochastic Stokes equations on the sphere

Q. T. Le Gia
University of New South Wales

Joint with Joseph Peach

We construct numerical solutions to a stochastic Stokes equations on the unit sphere with additive noise. The noise is expanded in a Karhunen-Loéve expansion in terms of the Hodge decomposition of tangential vector fields on the sphere. The approximation of the noise will give rise to a high dimensional approximation problem. Under certain assumptions on the angular power spectrum of the random noise, a mean square error estimate of the random solution is given. Numerical experiments are carried out to illustrate the theory.

References

[1] Varschalovich, A. N. Moskalev, and V. K. Khersonskii, Quantum Theory of Angular Momentum World Scientific, Singapore (2008).

[2] W. Freeden, M. Schreiner. Spherical Functions of Mathematical Geosciences, Springer-Verlag Berlin Heidelberg, 2009.

[3] D. Marinucci, G. Peccati, Random fields on the sphere. Representation, limit theorems and cosmological applications, Cambridge University Press, Cambridge, 2011.

***

Modelling and simulation of partial differential equations on random domains

Helmut Harbrecht
University of Basel

There are basically two methods to deal with partial differential equations on random domains. On the one hand, the perturbation method is based on a prescribed perturbation field of the boundary and uses a shape Taylor expansion with respect to this perturbation field to approximately represent the random solution. This yields a simple approach which, however, induces a model error. On the other hand, in the domain mapping approach, the random domain is mapped on a nominal, fixed domain. This requires that the perturbation field is also known in the interior of the domain but the resulting partial differential equation with random diffusion matrix and random load can be solved without systematic errors. In this talk, we present theoretical and practical results for both methods. In particular, we discuss their advantages and disadvantages.

***

On the Future of Sensitivity Analysis

Anthony Jakeman
Australian National University

Sensitivity analysis is being increasingly recognized as one of the essential means of exploring model behaviour and relative influences on model outputs. The aim of this talk is to summarize findings from a recent workshop at SAMO 2019 in Barcelona. It was held to explore some of the gaps remaining to be filled by SA, and to identify methodological opportunities that would expand the relevance of it. Example topics covered in the workshop on how SA can contribute to the future include:

- Advancing to a more structured, generalized and standardized approach to verification in mathematical modelling
- Assessing the sensitivity of complex, integrated models that combine many models (eg hydrology, ecology, economics, policy) that may well be of different types (eg numerical physical models, Bayesian networks, agent-based models) and where there might be feedbacks between models
- SA in support of model identifiability and informing the simplification of complex models with redundant components
- Algorithmic design to efficiently process simulation outputs
- SA as a means of characterizing the behaviour of natural systems (prior to modelling the systems), and new methodological opportunities to learn about sensitivities based on any given data about those systems.
- SA approaches for diagnostic testing of models, based on assessing similarities and differences between the behaviors of a model and the system that the model simulates.
- SA for assessing the robustness of uncertainty analysis results (with respect to epistemic and model uncertainties)
- SA-based methods for solving the issues of intelligibility and interpretability of machine learning (artificial intelligence) systems.

***

Uncertainty Quantification: An Overview

John D. Jakeman
Sandia National Laboratories

Credible prediction, certification, and design of complex systems requires assessment of uncertainties in the models and data used. Unfortunately, there is no well-defined process for assessing and communicating uncertainties. In this talk I will outline a set of basic steps which are essential for credible assessment of uncertainties. I will then discuss the algorithmic building blocks that enable tractable uncertainty quantification (UQ); touching on areas including forward propagation, multi-fidelity modeling, inference, optimal experimental design, coupled systems analysis, and design under uncertainty. This talk will target a broad audience from scientists and engineers interested in learning about UQ, to mathematicians and computer scientists developing new algorithms.

***

Quasi-Monte Carlo methods for uncertainty quantification using periodic random variables

Vesa Kaarnioja
University of New South Wales

Joint with Frances Y. Kuo & Ian H. Sloan

A popular model for the parametrization of random fields in uncertainty quantification is given by the so-called affine model, where the input random field is assumed to depend on independent, uniformly distributed random variables in a linear manner. In this talk, we consider a different model for the input random field, where the random variables enter the input field as periodic functions instead. The field can be constructed to have the same mean and covariance function as the affine random field. This setting allows us to construct simple lattice QMC rules that obtain higher order convergence rates, which we apply to elliptic PDEs equipped with random coefficients.

References

[1] V. Kaarnioja, F. Y. Kuo, and I. H. Sloan: Uncertainty quantification using periodic random variables, preprint arXiv:1905.07693 [math.NA].

***

Quasi-Monte Carlo Methods for PDE-constrained Optimization Under Uncertainty

Frances Y. Kuo
UNSW Sydney, Australia

Joint with Philipp Guth (University of Mannheim, Germany), Vesa Kaarnioja (UNSW Sydney, Australia), Claudia Schillings (University of Mannheim, Germany)
& Ian H. Sloan (UNSW Sydney, Australia)

Quasi-Monte Carlo (QMC) methods offer tailored point constructions for solving high dimensional integration and approximation problems by sampling. In recent years the modern QMC theory has been successfully applied to computational models in the field of uncertainty quantification involving partial differential equations (PDEs) with random coefficients. This talk will present new joint work between the teams at Mannheim and UNSW Sydney – we apply a QMC method to an optimal control problem under uncertainty, where the target function is the solution of an elliptic partial differential equation with random coefficients, steered by a control function. The robust formulation of the optimization problem is stated as a high-dimensional integration problem over the stochastic variables. One advantage of QMC in this context over other methods such as

sparse grid quadrature is that the equal and positive cubature weights of QMC preserve convexity of the optimization problem. A novel element in this work compared to previous works on QMC for PDEs is the need to work with coupled PDE systems (the "KKT system"), making some technical steps in the analysis rather challenging. Nevertheless, we obtain a complete L2 error analysis comprising the dimension truncation error, finite element discretization error, and QMC cubature error. Numerical experiments confirm our theoretical findings.

***

Robust Decision Making in Partially Observable World

Hanna Kurniawati
Australian National University

Robust robot operation must answer: What to do now, to receive good long-term returns, despite not knowing the exact effect of its actions, despite various errors in sensors and sensing, and despite limited information about the environment and itself. This problem itself is not new. Mathematically principled concepts --called Partially Observable Markov Decision Processes (POMDPs)-- have been developed more than five decades ago to address the problem mentioned above. However, such concepts are notorious for their computational complexity, that they have often been considered impractical. I will present some of our effort in addressing the computational complexity issues of solving POMDPs, and demonstrate that this decision-making concept has now become practical (to some extent) for solving various problems in robotics. I will end with a discussion on what this new capability could mean in bridging the gap between sensing and acting in robotics, and between planning and learning in general.

***

A spectral method for the stochastic Stokes equations on the sphere

Q. T. Le Gia
University of New South Wales

Joint with Joseph Peach

We construct numerical solutions to a stochastic Stokes equations on the unit sphere with additive noise. The noise is expanded in a Karhunen-Lo´eve expansion in terms of the Hodge decomposition of tangential vector fields on the sphere. The approximation of the noise will give rise to a high dimensional approximation problem.

Under certain assumptions on the angular power spectrum of the random noise, a mean square error estimate of the random solution is given. Numerical experiments are carried out to illustrate the theory.

***

Splitting methods: searching in the dark for a solution that might not exist

Scott Boivin Lindstrom
Hong Kong Polytechnic University

Many problems take on the general form of identifying a pattern (signal) with desirable qualities in a set of data. Such problems are often approached with plug-and-play machine learning tool sets like sci-kit learn (e.g. regression, support vector machines, neural networks). However, supervised methods assume the existence of some training data with a priori knowledge of correct results (categorical, numerical, or otherwise) that can be used to construct maps (learning). Unsupervised methods search without such a priori knowledge, but they generally only seek to satisfy some threshold ratio of desirability to complexity (e.g. clustering) rather than more complicated constraints that enforce high specificity for the solution.

In this talk, we will address a harder problem that is frequently encountered in engineering contexts: searching for a signal when high specificity is needed and only some limited measurements or structural information about the solution are available. Such problems are called ”feasibility problems.” We will explain how feasibility problems, together with many of the problems described above, fall within the more general framework of constrained optimization. We will explain how splitting methods are frequently employed to decompose the uncomputable parent problem into computable subproblems that may be used to guide the search for the solution. We will also show how some splitting methods may provide useful information even in cases when the feasibility problem has an empty solution set.

***

Computational modelling of strut defects in SLM manufactured lattice structures

Bill Lozanovski
RMIT University

Addition of manufacturing defects to computational models of 3D-printed lattice structures enable improved simulation accuracy. A computational model of a cellular structure based on finite element method (FEM) analysis, often starts from defect-free computer-aided design (CAD) geometries to generate discretised meshes. Such idealised CAD geometries neglect imperfections, which occur during the additive manufacturing process of lattice structures, resulting in model oversimplification. This research aims to incorporate manufacturing defects in the strut elements of a lattice structure, thereby enhancing predictive capabilities of models. In this work, a method of generating CAD AM representative strut models is proposed. The models are generated from micro-computer tomography (µCT) analysis of SLM fabricated struts. The proposed additive manufacturing (AM) representative strut FE model’s axial stiffness and critical buckling load is compared to idealised- and µCT- based FE models, with significant error reduction over idealised strut models. The AM representative strut models are then used to generate full lattice FE models and compared with manufactured and idealised FE models. The AM representative FE lattice models show greater correlations toward experiment and more realistic deformation behaviours. Overall, the methodology used in this study demonstrates a novel approach to representing struts in FE models of AM fabricated lattice Structures.

***

Investigating an uncertain Tsunami Simulation with B-splines on Sparse Grids

M. F. Rehme
University of Stuttgart

Joint with S. G. Roberts and D. Pfl˙uger

Many real world phenomena can not be thoroughly investigated, because they are rare, unanticipated or dangerous. Computer simulations provide a feasible framework to investigate these phenomena and modeling uncertainties in the simulations input parameters takes into account for the inevitably limited knowledge. To increase the accuracy of the predictions more uncertain input parameters can be added, but the run-times and necessary computational resources increase exponentially with the complexity of the model. Instead a surrogate model can be used to replace the original simulation, balancing accuracy and runtime appropriately.

We use Sparse Grids and B-spline basis functions for the creation of this surrogate model. Sparse Grids are a discretization scheme designed to mitigate the curse of dimensionality. B-spline basis functions are exactly integrable and provide gradients, making them a favorable choice in the context of uncertainty quantification. We demonstrate the capability of this approach based on the investigation of a tsunami simulation. First, we use the surrogate to better understand the underlying simulation through calculating stochastic key quantities such as means, percentiles and extrema. Then we solve the inverse problem of recovering the original values of the tsunami using Bayes inference.

***

Improving the efficiency and robustness of black-box optimisation

Lindon Roberts
Australian National University

In classical nonlinear optimisation, the availability of first-order information is crucial to constructing accurate local models for the objective and finding descent directions. However, when the objective function is black-box, computationally expensive and/or stochastic—which occurs in a variety of practical settings—gradients may be too expensive to compute or too inaccurate to be useful. In this setting, derivative-free optimisation (DFO) provides an alternative class of algorithm, which has grown rapidly in popularity and maturity in recent years.

In this talk, I will present new techniques for model-based DFO, which yield an improvement in the efficiency and robustness of existing methods. My focus will be on both general minimisation and nonlinear least-squares problems specifically.

***

UQ using Periodic Random Variables – a Fast Kernel Approximation Based on Lattice Points

Ian Sloan
University of New South Wales

This talk describes joint work with Vesa Kaarnioja and Frances Kuo (UNSW), and Yoshihito Kazashi and Fabio Nobile (EPFL, Lausanne).

In this talk (related to the one by Vesa Kaarnioja) we use kernel approximation based on periodic random variables and lattice rules to approximate the solution of an elliptic PDE with random field as input, with the random field itself assumed to be periodic with respect to the stochastic variables. The method is shown to give good (but not optimal) rates of convergence independently of truncation dimension, while being simple and cheap to implement.

***

Fairness risk measures

Bob Williamson
Australian National University

I will introduce the idea of fairness risk measures, which is an application of the theory of coherent measures of risk (a concept developed in mathematical finance) to problems of fairness in machine learning. I will explain the connection between this approach and the traditional approaches which are developed in terms of conditional independence and explain the advantages of the risk measures approach. I will also briefly relate the fairness risk measures to measures of economic inequality, and to an axiomatic approach to reasoning about fairness on the basis of preferences. Much, but not all, of what I will speak about is in the paper presented at ICML2019 with the same title.

***

Mixed methods of sensitivity analysis for studying the response surface and uncertainty of hydrologic models

Jing Yang
National Institute of Water & Atmospheric Research, New Zealand

Investigating the response surface of hydrologic model outputs is essential for understanding the associated hydrologic system and how model parameters and inputs affect those outputs. Sensitivity analysis has long been applied in environment modelling to aid model development, parameter screening and uncertainty quantification. In this study, sensitivity analysis is used to study the response surface of two hydrologic models: SWAT (Arnold et al., 1998) and TopNet (Bandaragoda et al., 2004). SWAT has been widely used for watershed hydrologic modelling and water quality simulation, while TopNet has been used as a national hydrologic model for flood prediction and flow simulation in New Zealand. Sensitivity analysis methods range from parameter screening methods (i.e. Morris method; Morris, 1991), to machine learning (Gaussian Processes) based on the Sobol' method (GPSobol; Oakley and O'Hagan, 2004), and Active Subspaces (Constantine and Diaz, 2017). Results show that for both hydrologic models, all three methods can be efficiently applied at a low computational cost. The Morris method can effectively screen out insensitive parameters, while whereas the Active Subspace method can identify the parameter optimization direction, and GPSobol can quantify the parameter contributions to modelling objectives, including parameter interactions. Similar results between Active Subspace and GPSobol demonstrate that both methods are not only useful for sensitivity analysis but also in exploring the response surface of these two applications (SWAT and TopNet). Machine learning methods like Gaussian Processes and Polynomial Chaos efficiently emulate desired Quantities of Interest of the response surface of the original model. The resultant emulations can be used not only to undertake sensitivity analysis but also to undertake uncertainty analysis, which is especially useful when the original model has long runtimes that inhibit sufficient sampling of the parameter space. Thus it can be used as a substitute for the original model. But the emulation can also identify insensitive parameters to fix in the original model and narrow the ranges of sensitive parameters for sampling (Yang et al.,2017).

***