# Outline and Summary of INI Research Programme 'Uncertainty Quantification for Complex Systems: Theory and Methodologies'

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# UQ

- Uncertainty quantification is the estimation and management of 'error' in the use of a computer code to simulate a real world system
- This error may result from uncertain inputs to the model.
- Or from the approximations (discretisation) used to go from the mathematics to the computer code
- Or from deficiencies in the original mathematical formulation (inverse modelling)

# Different Approaches

- Two communities have studied these problems
- The applied mathematics/numerical analysis community
- The statistics community
- Both approach the problem from different perspectives

# Programme Aim

The main aim of the programme is to bring applied mathematicians and statisticians together to formulate a common mathematical foundation for UQ and to establish long-lasting interactions that will lead to significant advances in UQ theory and methodologies for complex systems.

# Programme Organisers

- Catherine Powell - University of Manchester
- Max Gunzburger - Florida State University
- Henry Wynn - London School of Economics
- Peter Challenor - University of Exeter

# Programme Participants

- About 100 participants
- Average time at the INI 29 days
- About half from statistics; about half from applied maths/numerical analysis

# Workshops

We held four workshops:

- Key UQ methodologies and motivating applications
- Surrogate models for UQ in complex systems
- Reducing dimensions and cost for UQ in complex systems
- UQ for inverse problems in complex systems

and two open for business days

- Taming Uncertainty in Mathematical Models Used in the Private and Public Sectors
- Uncertainty Quantification for Complex Systems - Development in Theory and Methodologies

# Themes

- Surrogate models
- Multilevel, multi-scale, and multi-fidelity methods
- Dimension reduction methods
- Inverse UQ methods
- Careful and fair comparisons

# Today's Talks

- Surrogate Modelling - Max Gunzburger
- Design of Computational and Physical Experiments for Uncertainty Quantification - Dave Woods
- Uncertainty Quantification in Inverse Problems - Aretha Teckentrup
- Multilevel and Multi-Fidelity Methods - Richard Wilkinson

# Why no careful and fair comparisons

- One of our original themes was to produce careful and fair comparisions
- We found that this was almost impossible as the different methods actually tackled different, complementary problems
- Understanding different approaches and methods

# Some differences

- The applied mathematics/numerical analysis approach uses intimate knowledge of the form of the PDE to produce bounds on the error.
- The statistical approach treats the PDE as a 'Black Box' and models this as a random function giving a distribution for the error.
- These are very difficult to compare.

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- The statistical approach treats the PDE as a 'Black Box' and models this as a random function giving a distribution for the error.
- These are very difficult to compare.
- But we are working on it

# Personal Reflections

- It's been great fun (and still two weeks to go!!)
- Treating models as 'grey boxes'
- Combining the best from each approach