TGM Turing Gateway to Mathematics

CASE STUDY

Environmental Modelling in Industry Study Group

Background

The mitigation of severe environmental events and natural hazards is of huge importance. Mathematical modelling and analysis has the potential to help address challenges identified in this area. This 4 day workshop held in September 2015, facilitated the engagement of stakeholders in relation to the mitigation of extreme events and started to explore some specific challenges and possible solutions that mathematics can bring to these.

The TGM partnered with the Maths Foresees Network (as sponsor) and the PURE (Probability, Uncertainty and Risk in the Environment) Network to deliver this Study Group. Maths Foresees is an EPSRC network funded under the Living with Environmental Change umbrella to forge strong links between researchers in the applied mathematics and environmental science communities with end-users of environmental research.

Challenges

The main aim of this activity was to forge collaborations between the mathematical sciences and environmental change communities, to stimulate engagement to help facilitate other interdisciplinary collaborations and to the help set the context for future research activity.

The Study Group provided a forum to rethink the approach to the analysis of extreme weather events in order to help quantify uncertainty.

Other aims were to:

Better inform relevant academic mathematical and environmental science communities and environmental stakeholders on the mitigation of extreme environmental events.

Facilitate engagement between the various scientific communities and industry, in order to understand and gain consensus on the mathematical challenges that need to be overcome in order to ensure progress in the field.

"The study group brought together a wide range of academic experts and end-users of environmental research, which facilitated the development of a number of innovative solutions and insights relevant to industry."

- Dr. Tiffany Aslam, Maths Foresees Network Coordinator

Activity

Study Groups are designed to facilitate the investigation of real problems, by bringing together researchers and end users, such as from industry and Government, to work on new ideas and potential solutions. In this case, the event opened with the presentation of 5 Industrial Challenges, which were followed by study group sessions, where attendees self selected which challenge to work on over the following 2 and a half days. The event, which was attended by over 40 delegates, closed with the presentation of challenge solutions with associated discussion and exploration of possible next steps.

The challenges that were explored were:

- The Environment Agency (Spatial Rainfall Distribution in Flood Modelling).
- Fugro GEOS (Statistical Framework for Utilisation of Modelled Data for Tropical Cyclones).
- JBA Trust (Identification of Coherent Weather Features in Three Dimensions).
- The Met Office (Adjustment of a Column of Convectively Unstable Moist Air, and (Validating Convective-Scale Rainfall Forecasts and Estimating their Uncertainty).

Impacts

A number of potential solutions were identified and explored at the workshop. Following the event, collaborations between the end-users who set the challenges and the academics have continued, to develop short, peer reviewed reports that highlight the most promising potential solutions.

The Environment Agency (Spatial Rainfall Distribution in Flood Modelling)

The group sought to develop ways in which the methods currently employed by Industry can be maintained, while simultaneously generating more detailed surface water flood forecasts and reducing the computational time involved.
Discussion highlighted the challenge to identify coherent meteorological features in time and space from arrays of real or simulated data. This is crucial to understanding the processes occurring and to predicting how the atmosphere may evolve. The implementation of ideas for graph-based analysis to gridded meteorological data and provided example images generated using software was discussed.

Fugro GEOS (Statistical Framework for Utilisation of Modelled Data for Tropical Cyclones)

This group looked at producing synthetic datasets, using Monte Carlo methods which use repeated random sampling to generate numerical outputs. They compared the statistics generated from this approach, which can be used as a control, with the results from the existing approach used by industry. The group identified that reliable and complete data on tropical cyclone tracks is insufficient for reliable statistical conclusions. They proposed a statistical model for the generation of synthetic tropical cyclone tracks, as an inexpensive method to generate a large number of tropical cyclones where data is insufficient.

JBA Trust (Identification of Coherent Weather Features in Three Dimensions)

Activity involved developing a strategy to identify sets of features within weather data and to measure similarity between weather features on successive days. This could help atmospheric scientists understand how weather features evolve through time. Discussion highlighted that when modelling flood risk, spatially uniform rainfall inputs as well spatial uniformity in parameters that control the transformation of rainfall to runoff or river flow, are usually assumed. They identified possible ways to improve the quality of forecasting, to help reduce the risk of flooding from all causes, at a reduced cost in time and resources.

Met Office (Adjustment of a Column of Convectively Unstable Moist Air), and (Validating Convective-Scale Rainfall Forecasts and Estimating their Uncertainty)

One group explored gaining an understanding of the optimal rearrangement of blocks of moist convection and developing numerical and analytical solutions to model this. They constructed a numerical algorithm but found that different solutions may exist for the same initial data and suggest further work in how to devise computer code in practical forecasting. Another group looked at calculating the displacement metric between predicted and observed rainfall patterns and two different approaches from other fields of study were applied.

Turing Gateway to Mathematics
Isaac Newton Institute, 20 Clarkson Road
Cambridge, CB3 0EH, UK
tel: 01223 765580 **email:** info@turing-gateway.cam.ac.uk
web: www.turing-gateway.ac.uk