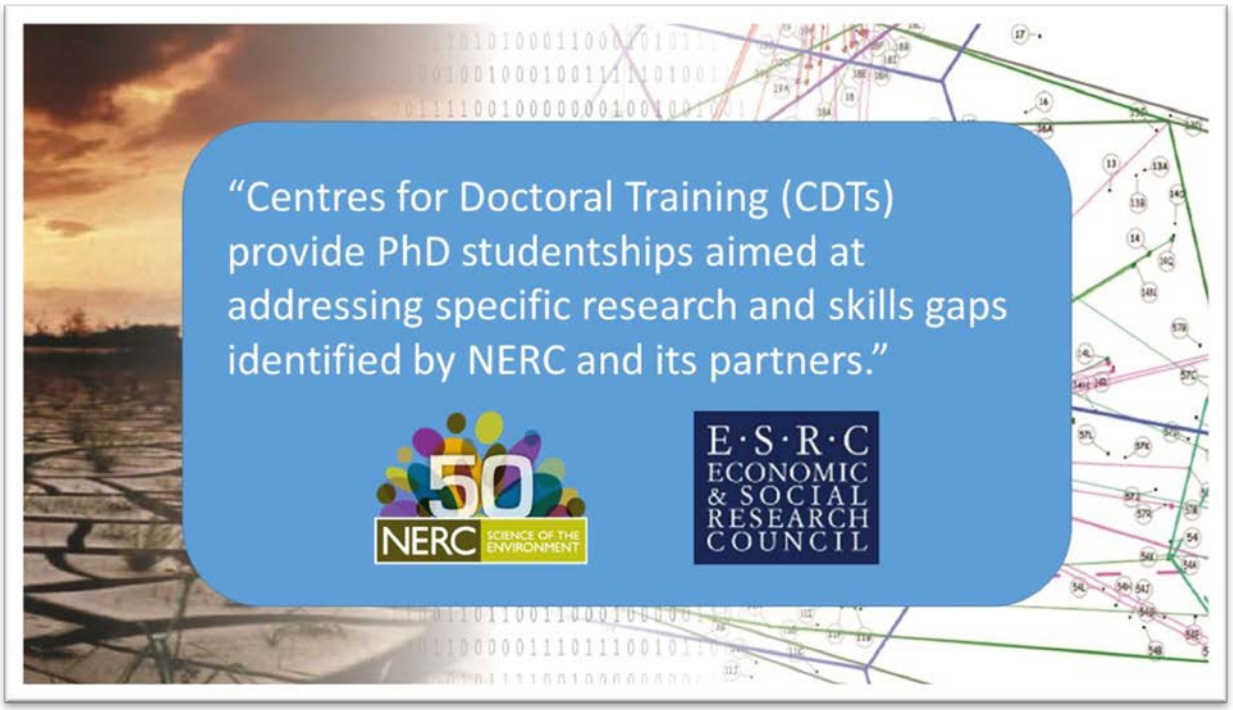
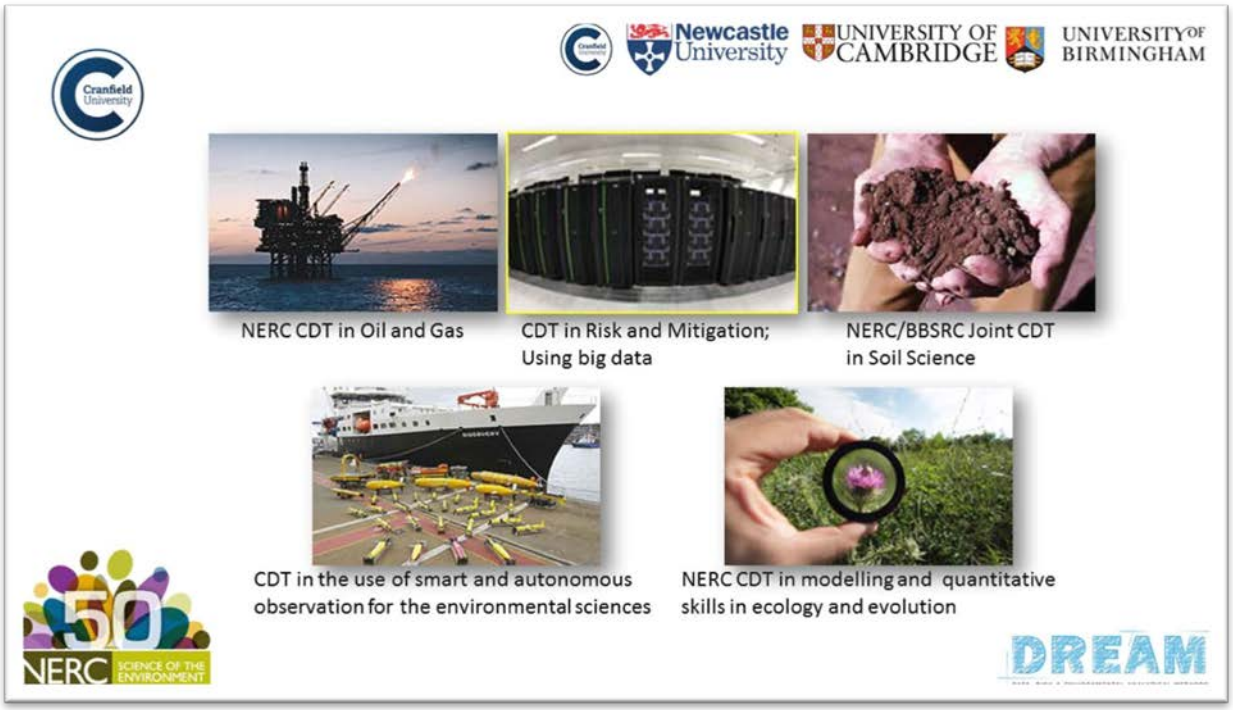
These are the notes of the presentation given by Dr Stephen Hallett, Cranfield University. Stephen heads up the 'DREAM' Centre for Doctoral Training, CDT, in 'Data, Risk and Environmental Analytical Methods', established between four leading Universities – Cranfield, Newcastle, Cambridge, and Birmingham. http://www.dream-cdt.ac.uk.



The DREAM centre represents the four universities – Cranfield University, the University of Cambridge, Newcastle University & the University of Birmingham. Sponsored by NERC and ESRC, a CDT provides PhD studentships aimed at addressing specific research & skills gaps identified by the research councils & partners. Ours considers Big Data and Env. Risk.



Currently there are five NERC CDT Centres, with more planned, covering the broad range of strategic research priorities of NERC – these comprise Oil & Gas, Soil science, Autonomous observation, Quantitative ecology – & Risk & Mitigation using Big Data – DREAM ('Data, Risk and Environmental Analytical Methods').

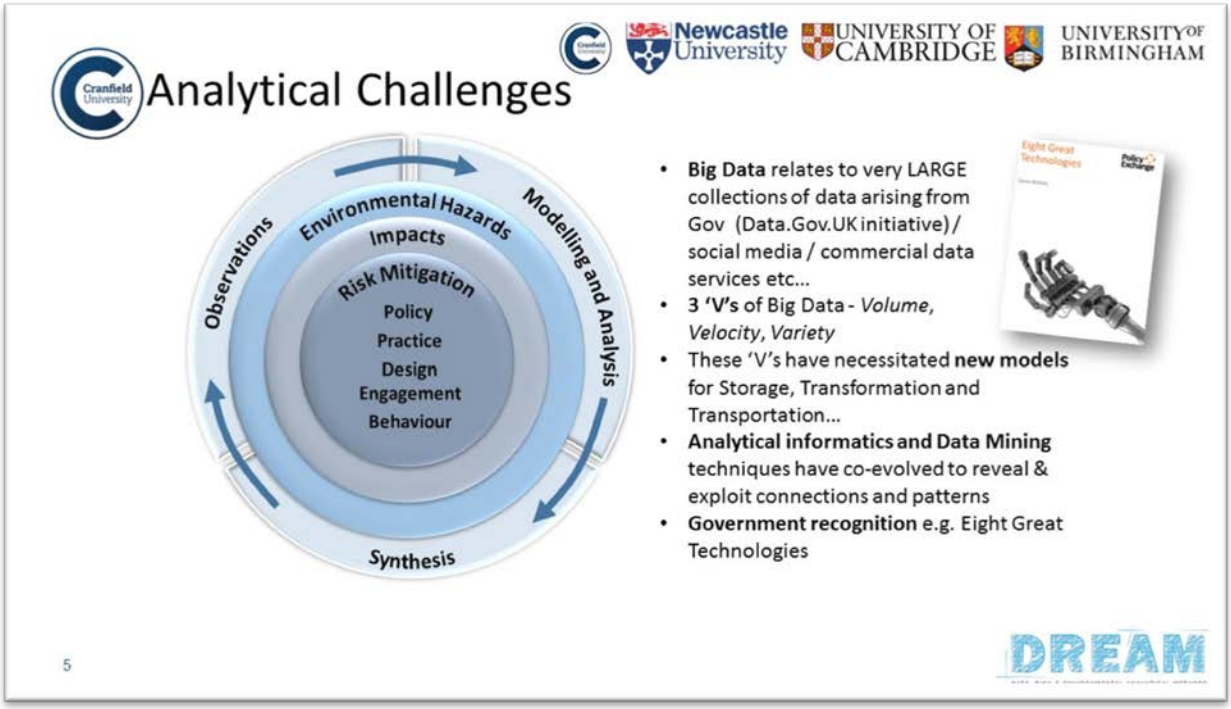
Doing a PhD now very different from when colleagues here may remember. There is a huge emphasis now across the CDTs in training and skills, and collaborative approaches.

The DREAM consortium recognises that the grand challenges of mitigating environmental risk are many & varied:

(1) To develop systems allowing for real time hazard assessment & rapid risk mitigation over short time period to address impacts occurring as a result of extreme unexpected events of low frequency, high magnitude & often with massively destructive outcomes in terms of human, financial and environmental cost & damage, e.g. major flooding, geohazards & extreme weather events.

(2) Developing approaches that avoid systemic system failure as a result of potentially extreme events & long term environmental hazards. In such cases foci of impact of an event or the long-term hazard may well propagate & cascade through the system starting with seemingly insignificant consequences but ultimately leading to massive failure (this is the so-called butterfly effect). The US National Science & Technology Council recognises systemic failure of critical infrastructure as one of the grand challenges in disaster reduction.

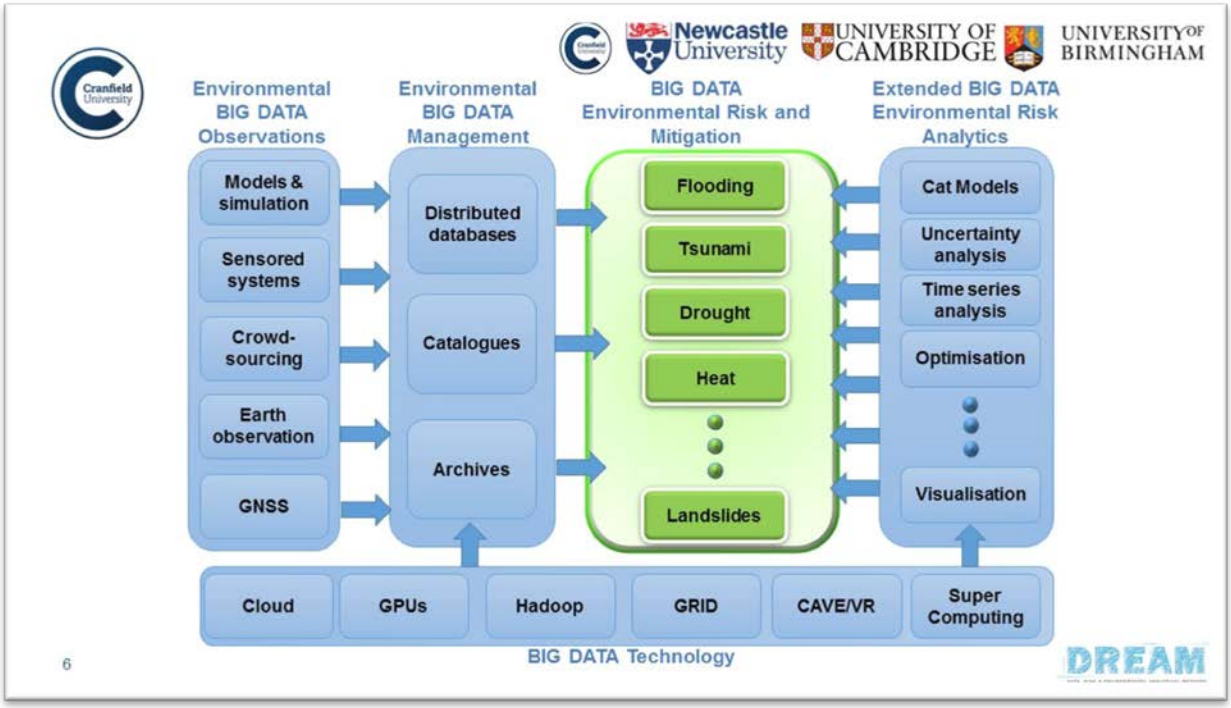
(3) Long term environmental perturbation & stressing of a system to the point where impacts become chronic & irreversible. For example, long term multi-decadal geobiophysical effects such as soil degradation & reduced productivity of agricultural land. Here the challenge is to understand the long-term processes at play & in what circumstances & when they lead to irretrievable degradation & the mitigation actions required to avoid this.



The previous grand challenges & the improved/new approaches required can be expressed as three fundamental major analytical challenges faced by the environmental sciences; namely, (1) improved observations & measurements, (2) improved coupled models & analysis approaches, & (3) improved synthesis & translation of data & results.

The view in DREAM is that all three can be successfully addressed by leveraging of the Big Data technology & techniques. Indeed, we believe that a key characteristic of DREAM and its research is the broad focus across not only observation & measurement but also modelling/analysis & synthesis/translation. Big Data technology & techniques have a critical role in assisting the capture & management of 100s of terabyte to petabyte data volumes.

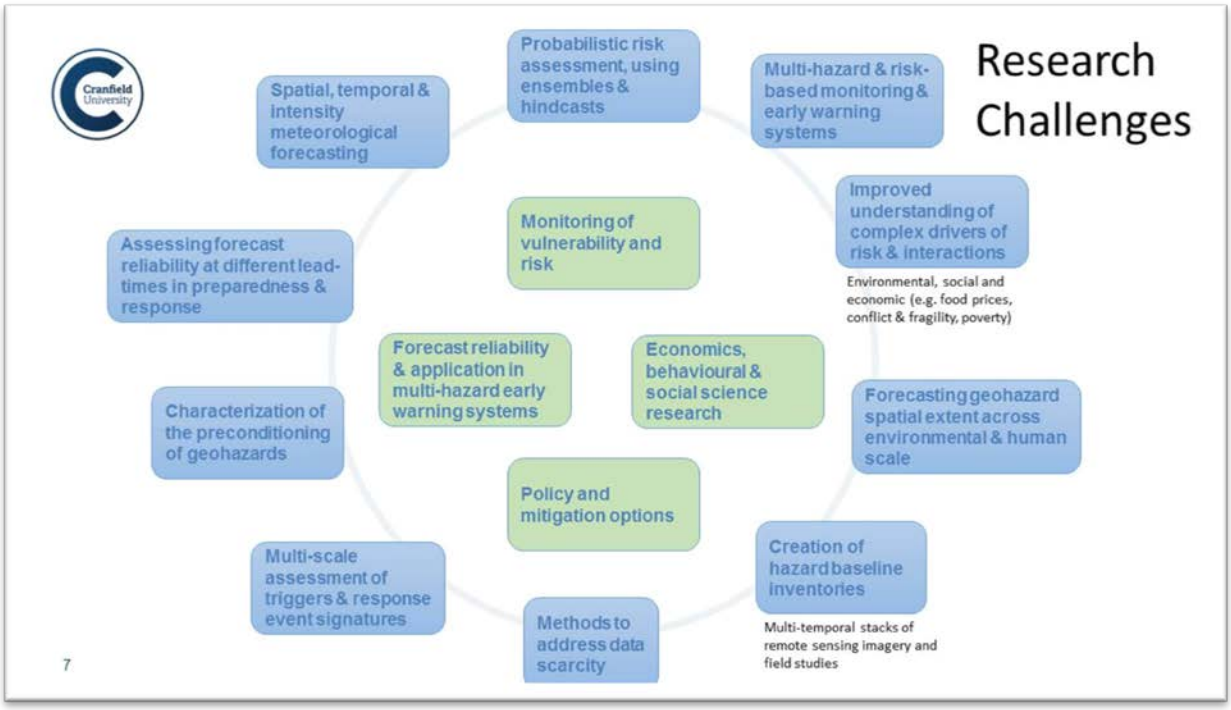
We also believe that Big Data technology and techniques have an essential role in real time & re-analysis predictive modelling, particularly with respect to ensemble generation & uncertainty characterisation of environmental hazards such as flooding, drought & water resources etc. Moreover, Big Data techniques & technology also has critical role in agent-based models of humane behaviour & response in testing mitigation policies.



Thus in DREAM we see role of Big Data as one of the science of knowing when & where to employ the most appropriate Big Data computational technology & techniques. DREAM students trained in the field of Big Data science will hopefully recognise the multiple skills & understanding that will be required by future environmental science across areas of data observation, data management, modelling/analysis in order to provide suitable computational mitigation frameworks.

Underpinning our approach to Big Data science for risk mitigation is the recognition that science itself needs to leverage the most appropriate technologies & techniques for the particular problem being investigated. Thus, while we fully recognise the critical & key role that cloud computing will play in the future, we also recognise that other HPC technologies have critical roles to play such as Hadoop and SPARK in handling the next generation of high-volume distributed databases, archives & catalogues, GPUs in undertaking spatial-topological environmental modelling in fields such as fluvial & hydrodynamic modelling, as well as CAVE & immersive VR, & HPC environments in delivering the decision support framework for appropriate representation of risk mitigation options.

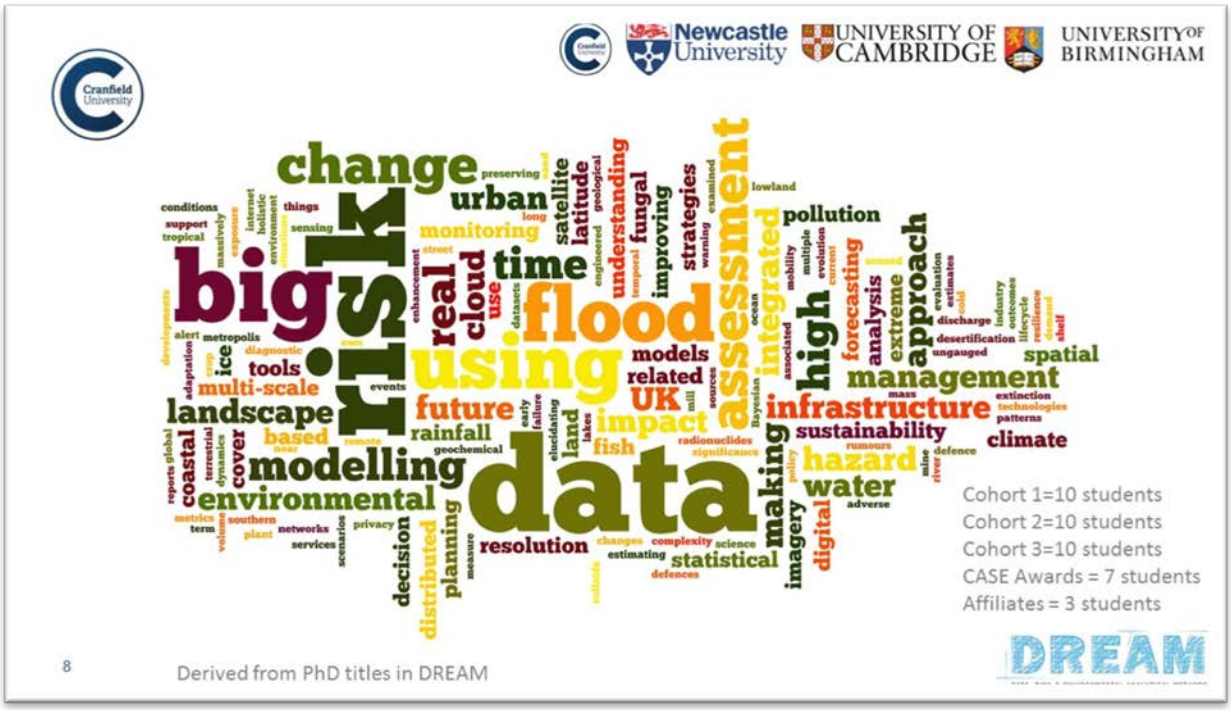
Students need to gain skills across Big Data areas including utilisation of disparate, multivariate data feeds ranging from Earth observation to crowd sourced and social media data, with skills in the use of Big Data techniques for managing distributed databases & massive data archives, as well as experience in the application & development of analytical computational tools that can leverage these resources.



There are a number of research challenges our students seek to address. Recent science & technological developments offer now new opportunities to overcome long-lived barriers in characterising & mitigating a range of environmental hazards, & the ability to provide relevant risk focused information to affected communities & managers. In seeking to represent here NERCs interests around risk science and researching risk, I can relay a few of the ways science-based approaches can offer improvements, there are 10 themes.

1. Probabilistic decision-making frameworks for geohazard forecasting, with coupled model frameworks incorporating evaluation of uncertainty, and use of ensembles & hindcasts to generate databases of possible events & probabilities;
2. Building multi-hazard & risk-based monitoring & early warning systems;
3. Improved understanding of the complexity of the drivers of risk;
4. Forecasting maximum spatial impacts of geohazards at scales across environmental & human interaction settings, providing relevant information to communities & managers;
5. Creation of hazard baseline inventories, e.g. interpretation of multi-temporal stacks of remote sensing images, coupled with field survey – Afghanistan;
6. Methods to address data scarcity, e.g. flood risk modelling for un-instrumented catchments – we have for example research underway in Mexico addressing this;
7. Multi-scale assessment of environmental triggers, exploiting recent advances, for instance in remote sensing – Work in Libya is addressing this;
8. Characterization of the preconditioning of geohazards & contribution to processes such as progressive failures at sub-seasonal to seasonal time scales, e.g. Persistent Scatterers Interferometry (PSI) - a remote sensing technique offering the potential for near real-time ground movement monitoring over wide areas – work in the East Anglian region of the UK is addressing this;
9. Assessing the reliability of forecasts at different lead-times in disaster preparedness & response; from a statistical and socioeconomic perspective (represented by those projects we have having ESRC support funding);

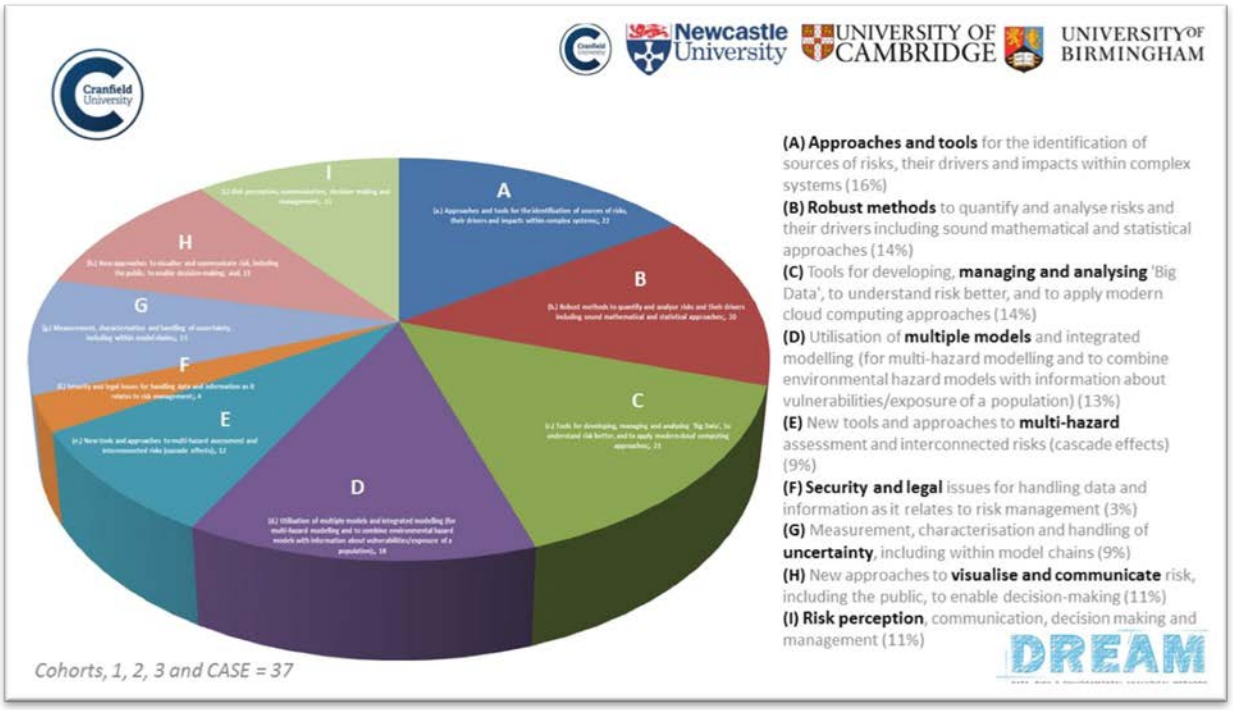
10. Spatial, temporal & intensity forecasting of weather event sequences influencing a range of geohazards, including convective storms & other high- intensity rainfall events.



This infographic is to save having to list out each of the many thesis titles for DREAM researchers

The graphic covers all of the 30 DREAM projects, plus we are fortunate to have a new tranche of 7 CASE awards being recruited currently, plus a number of affiliate Doctoral studies underway.

A good impression is given here of the sheer breadth of the research (described fully on the Dream website). We see a core focus on the use of big data addressing risk. The themes of interest perhaps inevitably focus strongly on flooding & flood response, although land degradation & desertification, infrastructure, pollution, coastal management, fish stocks, bioinformatics, illicit crops, multispectral crop sensing, the energy trilemma, land restoration & radionuclide disposal are covered, as well as others.



Our task in DREAM was to be able to direct the research across nine key areas: Approaches and tools; robust methods; tools for managing analytics; use of multiple models; multi-hazard approaches; security and legal aspects of the data; handling uncertainty; and means to visualize and communicate risk with tools to aid risk perception. The chart here shows the split of the projects we are supporting under these areas.

The governance structures in DREAM consortium provide a great strength to the Centre, & ensure its international academic, & industrial relevance.

The DREAM management board is supported by the international advisory board, & the industrial advisory board. Also shown are a broad selection of the industrial organisations & research institutions who have indicated their willingness to engage with and co-sponsor DREAM research.

Finally try & give a flavour of what it is like 'Researching uncertainty' in DREAM. We have an extremely vibrant community of research practice across the four institutions. Each student receives extensive advanced technical training across themes including High Performance Computing; Informatics; Numerical skills; Modelling; Risk Analysis, & Environmental Analysis. Students also receive extensive 'soft-skills' training – making presentations, writing papers, visual communication, teamwork, time management & so forth.

As this show there is plenty of scope to bring students together to work collectively on shared projects. We have our "Annual Symposium & 360 degree industrial seminars (from the likes of Microsoft, Google & ESRI) – the last being held recently in Cambridge. We will shortly have our second "Challenge Week" in Birmingham.

To conclude with some final thoughts:

- Decision makers in business, government & society need to understand the risks faced & develop appropriate mitigation strategies;
- Our society & environment are increasingly susceptible to changes associated with a fast expanding & ageing population, highly interdependent economies, increasingly limited resource, natural hazards & rapid climate change. The complex, interdependent & rapidly changing risks derived from these interacting drivers, often results in unexpected impacts, far removed from the original trigger;
- There is an urgent need for tools and techniques to help decision makers assess risk from increasingly complex interconnected hazards, to understand the uncertainties associated with them, to communicate risk & enable decision-making under uncertainty.

The DREAM Centre for Doctoral Training (CDT) seeks to address the increasing & emerging skills needs in this area, providing an opportunity to strengthen the flow of knowledge & skilled people, into research & practice, & to guide policy making at all levels from local to national to international. If you are interested in learning more, please do get in touch.