PostGraduate Institute for measurement science

5th ANNUAL CONFERENCE

NEXT GENERATION METROLOGY
A VIRTUAL PLATFORM FOR INNOVATION

SEPTEMBER 2020 PROGRAMME

NPL National Physical Laboratory

University of Strathclyde

University of Surrey

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The Postgraduate Institute for Measurement Science

The Postgraduate Institute was developed through a strategic partnership between the National Physical Laboratory (NPL), the UK's National Measurement Institute, owned by the Department of Business Energy and Industrial Strategy (BEIS), and partnered with the University of Strathclyde and the University of Surrey. The PGI is a leading institute for postgraduate research and training in measurement science and its application to physical, engineering, biological and chemical sciences in the UK. The PGI is creating a pipeline of talented researchers skilled in measurement science and its applications to benefit industry and wider society.

The PGI is currently partnered with over 30 higher education institutions and many industry partners. We have over 200 postgraduate researchers producing top quality research spanning many scientific disciplines – from manufacturing and life sciences to data and the environment. The discoveries they are making contribute significantly to the UK's position at the forefront of innovation in measurement science.

The aim of the PGI to create the next generation of world-class measurement scientists is achieved through its unique positioning at the interface between academia and industry. As such, the PGI is a gateway for companies and research organisations looking to understand and utilise measurement in order to perform research and innovate. Our students work on important challenges, with many uniquely placed to provide the resource and solutions needed to accelerate the translation of research and create impact on commerce and quality of life. This conference showcases examples and highlights the pioneering research carried out within the PGI.

Telephone: 020 8977 3222
Email: pgi@npl.co.uk
Website: www.npl.co.uk/pgi
Twitter: @PGImetrology and #PGIconference
Instagram: pgimetrology

Urgent contacts during conference
If you have questions or queries for the Committee, please do not hesitate to contact us.
Email: PGIconference@npl.co.uk
Phone: 07775 030 265 or 07976 518 807

Welcome Letter from the Conference Committee

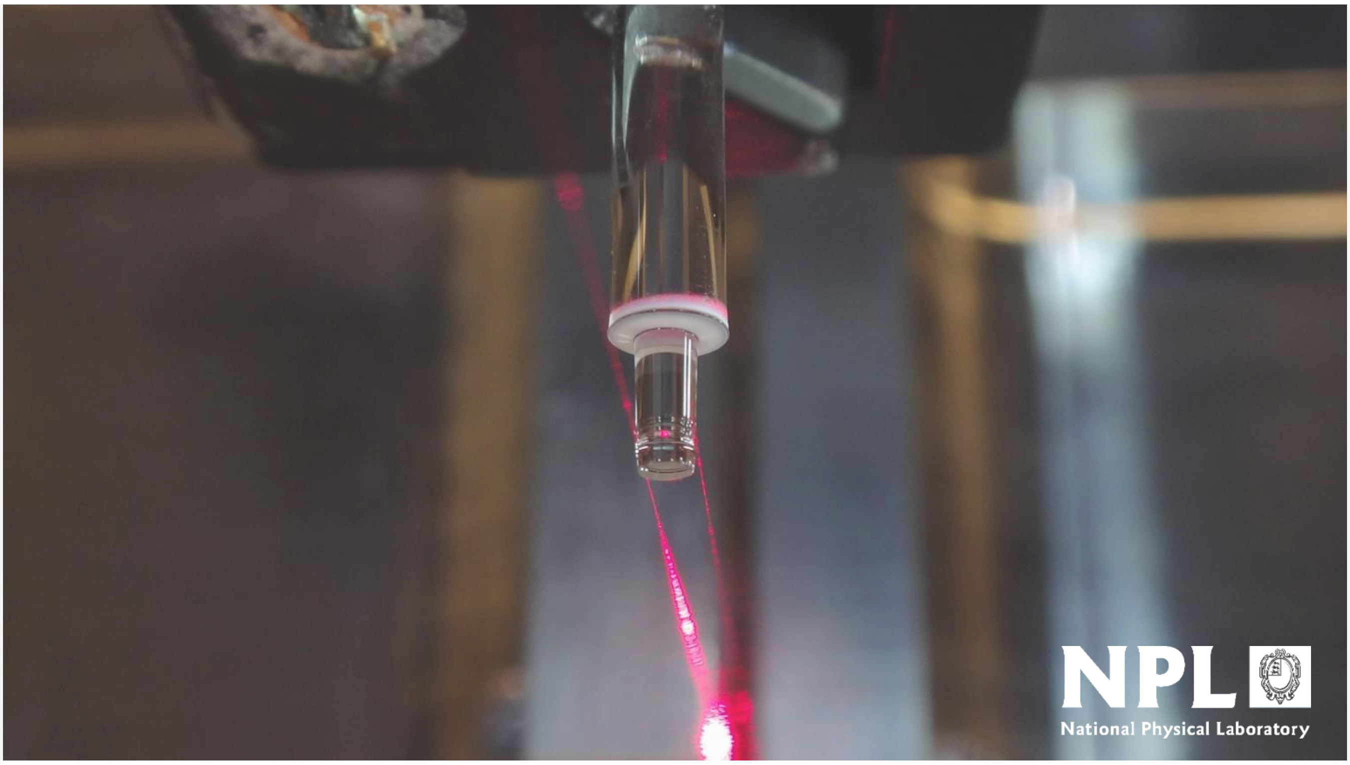
We are delighted to be able to host the 5th annual PGI Conference in such challenging times, and we are excited that it will be our first on-line PGI conference! We wish to build on the success of previous years by giving our PGI researchers, and other students, supervisors and delegates from academia and industry an opportunity to engage with other participants from a variety of backgrounds and locations. Although we will not be able to meet in person and will undoubtedly miss the all-important PGI social event, this year's programme has been developed to maximise interaction. We will actively encourage delegates to contribute through the chat function in Teams during the Q&A sessions and the discussion period after the talks. As with previous years, we will showcase how our PGRs bring to life the science and engineering of measurement and look forward to a continuation of last year's popular career development session.

This is the time to turn a challenge into an opportunity for all our students, to get involved and flourish in the digital experience of attending, presenting, organising, and networking at an online conference. The opportunity for the PGI to create and develop links with academia and industry has proven valuable each year, and we hope that this year will be the same.

We would like to welcome you to this year's online conference, we wish everyone an enjoyable experience and hope to see you all in person next year!

About NPL

National Physical Laboratory (NPL)



NPL is the UK's National Metrology Institute, providing the measurement capability that underpins the UK's prosperity and quality of life.

From new antibiotics to tackle resistance and more effective cancer treatments, to secure quantum communications and superfast 5G, technological advances must be built on a foundation of reliable measurement to succeed. Building on over a century's worth of expertise, our science, engineering, and technology provides this foundation. We save lives, protect the environment, and enable citizens to feel safe and secure, as well as support international trade and commercial innovation. As a national laboratory, our advice is always impartial and independent, meaning consumers, investors, policymakers, and entrepreneurs can always rely on the work we do.

Based in Teddington, south-west London, NPL employs over 600 scientists. NPL also has regional bases across the UK, including at the University of Surrey, the University of Strathclyde, the University of Cambridge, and the University of Huddersfield's 3M Buckley Innovation Centre.

Find out more: npl.co.uk

Registration and Joining Instructions

Registration

The sessions are online, free and are designed to be flexible, so do join us for all of them or just the session's you are most interested in. Sessions are open to all, but you must register beforehand if you intend to join.

To register, please visit Eventbrite via this link

How to join on the day

Below are links to join each session on the specified day/time during September.

- Only click on the correct link on the date and time of the conference session.
- The links are for Microsoft Teams and you don't need to install an app or plugin to access them. On the day, the link will work through your usual internet browser.
- Please keep your microphone and camera off when joining, and during any talks. However, it will be permitted to turn these on if you wish, for the Q&A sessions.

Session 1: Tuesday 8th September, 11am-1pm – Engineering solutions for tomorrow's challenges

Session 2: Tuesday 15th September, 11am-1pm – Metrology for the digital age

Session 3: Tuesday 22nd September, 11am-1pm – Carbon net zero

Session 4: Tuesday 29th September, 10am-1pm – Career Workshop

If you have any queries, please email pgi@npl.co.uk

Programme

Day 1 *Tuesday 8th September*	
	Opening Session Chair: David Connolly
11.00 – 11.10	**Welcome:** Richard Burguete, PGI Director, National Physical Laboratory
	Session 1: Engineering Solutions for Tomorrow's Challenges
11.10 – 11.45	**Keynote: The Future of Engineering** *Dr Rachel Cooke; Senior Reliability Engineering Manager, Amazon Europe*
	Student Talks
11.45 – 11.55	**Bioelectronic Scaffolds: The Future of Drug Testing** *Dannielle Cox-Pridmore, University of Surrey*
11.55 – 12.05	**Enhancing Process Control in High Value Manufacturing with Phosphor Thermometry** *Fraser McCallum, University of Strathclyde*
12.05 – 12.15	**Electrical energy metering beyond standards requirements** *Renán Quijano, University of Strathclyde*
12.15 – 12.25	Q&A
	Poster Sessions
12.25 – 12.50	Poster Session 1 – **Active Photonic Thermometry** *Anoma Yamsiri, University of Surrey*
	Poster Session 2 – **A homodyne displacement measuring interferometer with real time non-linearity correction** *Angus Bridges, Cranfield University*
	Poster Session 3 – **Predicting failure location in device embedded substrates to enable the next generation of electronics miniaturisation** *Dan Flintoft, University of Surrey*
	Poster Session 4 – **Pancreatic ductal adenocarcinoma tissue engineering to support hypoxic radio-resistance profiling** *Gabrielle Wishart, University of Surrey*
	Poster Session 5 – **Towards wafer scale minority carrier lifetime mapping using a compressive sensing approach** *Aidas Baltušis, University of Surrey*
12.50 – 13.00	Wrap Up
	Online Networking

Day 2 Tuesday 15th September	
	Opening Session; Chair: Keir Murphy
11.00 – 11.10	**Welcome:** Richard Burguete, PGI Director, National Physical Laboratory
	Session 2: Metrology for the Digital Age
11.10 – 11.45	**Keynote**: **Metrology for the Digital Age** *Dr Stuart Kitney; Head of Department, Data Science, National Physical Laboratory*
	Student Talks
11.45 – 11.55	**Interlaboratory evaluation of MALDI and DESI MSI in the CRUK Grand Challenge programme** *Melina Kyriazi, Imperial College London*
11.55 – 12.05	**Data clustering for fast identification of twisted bilayer graphene** *Tom Vincent, Royal Holloway, University of London*
12.05 – 12.15	**Characterising an evanescent field for large field of view illumination in mesoscopic imaging** *Shannan Foylan, University of Strathclyde*
12.15 – 12.25	Q&A
	Poster Sessions
12.25 – 12.50	Poster Session 1 – **Unsupervised learning with Gaussian processes and stochastic differential equations** *David Fernandes, Bath University*
	Poster Session 2 – **Securing Digital Calibration Traceability in Safety-Critical IoT** *Ryan Shah, University of Strathclyde*
	Poster Session 3 – **Ultra-Precision Machining of Silicon Lamellae with minimal sub surface damage** *Declan Cotter, University of Cambridge*
12.50 – 13.00	Wrap Up
	Online Networking

Day 3 *Tuesday 22nd September*	
	Opening Session
11.00 – 11.10	**Welcome;** Richard Burguete, PGI Director, National Physical Laboratory
	Session 3: Carbon net zero
11.10 – 11.45	**Keynote**: **Achieving Net Zero carbon emissions by 2050: The challenges ahead and the role of measurement science** *Dr Neil Jennings; Partnership Development Manager, Faculty of Natural Sciences, The Grantham Institute for Climate Change*
	Student Talks
11.45 – 11.55	**Improving Network Visibility for Better Integration of Low Carbon Technologies into LV Networks** *Allison Strachan, University of Strathclyde*
11.55 – 12.05	**Next-generation perovskite photovoltaics: ion-driven degradation through nanograin formation** *Filipe Richheimer, University of Surrey*
12.05 – 12.15	**Assessing London's methane emissions and sources through high-frequency atmospheric measurements and simulations** *Eric Saboya, Imperial College, London*
12.15 – 12.25	Q&A
	Poster Sessions
12.25 – 12.50	Poster Session 1 – **Inferring London's methane emissions from atmospheric measurements** *Daniel Hoare, University of Bristol*
	Poster Session 2 – **3D Modelling of Methane Isotope Ratios** *Alice Drinkwater, University of Edinburgh*
	Poster Session 3 – **Toward traceable thermal imaging of nuclear waste containers** *Jamie McMillan, University of Surrey*
12.50 – 13.00	Wrap Up
	Online Networking

Day 4 *Tuesday 29th September*	
	Opening Session
10.00 – 10.10	**Welcome;** Richard Burguete, PGI Director, National Physical Laboratory
	Session 4: Career Development Session
10.10 – 10.50	**Career talks** *Professor Karen Faulds (University of Strathclyde)* *Dr Matat Jablon (Oxford Instruments)* *Yi Luo (Dept of Business Energy and Industrial Strategy)* *Christian Jones (Nanoform Technologies)* *Sanjiv Sharma (Airbus)*
10.50 – 11.10	Q&A
11.10 – 11.20	**Coffee Break**
11.20 – 12.20	**CV and Interview Tips Session** *Dr Dorothy Evans & Hanna Maclachlan*
12.20 – 12.40	Q&A
12.40 – 12.50	*Closing remarks*
12.50 – 13.15	**Online Networking**

National Physical Laboratory

Keynote Speakers

Rachel Cooke; Amazon Europe

Rachel leads Reliability Engineering for Amazon Europe, which includes robotics, reliability programs, training, predictive analytics (machine learning), computerized maintenance management systems, new technology introduction and new site launches.

Previously, she was Head of Central Programs and Capability for Amazon Engineering Services Europe, where she led several teams that supported the growth of Amazon's warehousing capacity. Prior to this she was responsible globally for manufacturing performance measurement and operational excellence for SABMiller (FTSE-10), who were the world's second largest brewer by volume with over 100 operations worldwide in Africa, Asia Pacific, Europe, Latin America, and the USA. Before this she led a team delivering a portfolio of product change initiatives from project initiation through to implementation and launch at Cadbury.

Dr Cooke has spent three years living in Poland, working on the design, construction, and commissioning of two new-build confectionery factories and currently lives in Luxembourg. In her spare time, she is a founding director of the Cheltenham Science Group, who run a non-profit hands-on science centre and is an awards judge, chartership interviewer and assessor for the Institution of Chemical Engineers. She has a top starred first and PhD in Chemical Engineering from the University of Cambridge.

Stuart Kitney; National Physical Laboratory

Stuart is the Head of Department for Data Science at the National Physical Laboratory. An organic chemist by training, Stuart graduated in 2003 with a first-class honours MChem (four-year course with one-year Industrial Placement at Johnson Matthey Royston) from the University of Hull. He gained his Post-Graduate Certificate in Education in 2006 and PhD in 2008, from the University of Hull.

As a Head of Department at NPL, Stuart is a member of the Senior Leadership team, who are responsible for ensuring NPL's science and engineering capability remains world leading and is developed for the future including people, scientific facilities and equipment. The Data Science team, develop techniques to improve the quality, traceability and reliability of data, as well as understanding measurement uncertainties. Their aim is to embed measurement data into a trusted digital infrastructure that will underpin future traceability chains. Whether developing models for carbon savings of new technologies or applying data analytics to develop new medical treatments, their work helps organisations make decisions driven by robust and reliable data.

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Neil Jennings; The Grantham Institute for Climate Change

Neil is responsible for supporting the development of strategic partnerships with policymakers, business, and non-governmental organisations. He has a specific interest in the co-benefits of climate action – how tackling climate change can help create a cleaner, greener, fairer future and how these co-benefits can be better considered in the decision-making process.

About the Grantham Institute - The Grantham Institute aims to drive highly collaborative climate and environment-related research that has a real-world impact. The Institute harnesses the tremendous strengths of world-class researchers from Imperial College London's four main areas – engineering, natural sciences, medicine, and business – and external partners to address climate change and environment related issues. The impact-focused nature of this research ensures it is influential in informing fundamental understanding of climate processes to environmental impacts, mitigation technologies and policies.

Career Session Speakers

Dr. Dorothy Evans; National Manufacturing Institute Scotland (NMIS) Doctorate Centre, University of Strathclyde

Dorothy leads the NMIS Doctorate Centre on all strategic and operational activities, focusing on cross-industry based research which offers students and graduates a unique opportunity to carry out in-depth study and research in advanced manufacturing techniques. She works across the different centres such as the Advanced Forming Research Centre (AFRC), Lightweight Manufacturing Centre (LMC) and the Digital Factory, as well as across the Engineering Faculty at the University of Strathclyde. She manages the PhD and Engineering Doctorate students linked with research that is either funded by these centres or directly funded by Industry. Dorothy is an experienced Project Manager, with a masters and doctorate in design management, and has extensive experience in managing complex design, multi-technology projects through to successful conclusion. She has been pivotal in establishing the Doctorate Centre within NMIS and managing a network of Graduates, Academics, Industry Sponsors and Companies across a widespread, geographical region. Her current research activities include sustainability of the Doctorate centre after government funding. She has extensive experience in recruiting and managing students through the duration of their PhD’s/EngD’s. She undertakes Supervision as well as External Examining of PhDs at other universities.

Hanna Maclachlan, National Physical Laboratory

Hanna is a Talent Acquisition Specialist working within the HR department of NPL. For the past, 9 years she has recruited a range of professionals from technical fields in including Science, Engineering, IT and Construction from all different industries. Hanna has also been involved in early careers recruitment with Graduate and Apprenticeship Programmes across these fields where she has helped people of varying backgrounds. from school leavers to PhD graduates, find employment.

Matat Jablon; Oxford Instruments

Matat is originally from New York. She studied for a bachelor’s degree in earth and planetary sciences at Johns Hopkins University in Baltimore, Maryland and then moved to Israel where she served in the army and then completed a master’s degree in Geology at the Hebrew University of Jerusalem. She worked for two years at the university as an electron microscopy technician before moving to Scotland and studying for a PhD in Physics at Strathclyde and NPL specializing in advanced electron microscopy techniques, and is now an Alumna of the PGI.

She is now an applications and field service engineer for **Oxford Instruments** in France, where she works on advanced applications in electron microscopy using energy dispersive spectroscopy and electron backscattered diffraction. Matat develops applications, software and techniques for customers and provides sales support, instrument demonstrations, scientific talks at conferences, marketing talks and continuing education for customers in advanced electron microscopy techniques.

Prof. Karen Faulds; University of Strathclyde

Karen Faulds is a Professor in the Department of Pure and Applied Chemistry at the University of Strathclyde and an expert in the development of surface enhanced Raman scattering (SERS) and Raman techniques for novel analytical detection strategies and in particular multiplexed bioanalytical applications. She has published over 130 peer reviewed publications and has filed 5 patents. She has been awarded over £20M in funding as principal and co-investigator from EPSRC, BBSRC, charities, industry, and governmental bodies. Her Groups research has been recognised through multiple awards including the Nexxus Young Life Scientist of the Year Award (2009), Royal Society of Chemistry (RSC), Joseph Black Award (2013), Craver Award (2016) and Charles Mann Award (2019). She is a Fellow of the Royal Society of Chemistry (2012), the Society for Applied Spectroscopy (2017) and the Royal Society of Edinburgh (2018). She was named one of the Top 50 Women in Analytical Science (2016) and Top 10 Spectroscopists (2017) by The Analytical Scientist. She has given over 80 invited talks at national and international conferences.

She was elected as the first female and youngest Chair of the Infrared and Raman Discussion Group (IRDG) in 2014 which is the oldest spectroscopic discussion society in the UK and a FACSS member society. She is also an appointed member of the Royal Society of Chemistry (RSC) Chemical Biology Interface Division Council and a member of the International Steering Committee of the International Conference on Raman Spectroscopy (ICORS). She is the Strathclyde Director of the EPSRC and MRC Centre for Doctoral Training in Optical Medical Imaging joint between the Universities of Edinburgh and Strathclyde, serves on the editorial board of RSC Advances and the editorial advisory board for Analyst, Chemical Society Reviews and Analytical Chemistry.

Christian Jones; CCO of Nanoform Finland Plc.

Christian is the Chief Commercial Officer for Nanoform Finland Plc and leads the commercial activities for the company. In his role he works with Pharma and Biotech partners to enhance their drug molecules by rapidly improving their solubility and bioavailability through the application of Nanoform's proprietary solution to nanoparticle technology. He has a strong track record commercially in Drug Substance (DS) and Drug Product (DP) Development and Manufacturing services, Technology Development and Commercialisation, Sales and Marketing and Strategy Development and Implementation.

Christian has a strong knowledge of the healthcare market with global experience and an ability to quickly understand how best to strategically leverage an organisation's strength to maximise success. He has experience of working across the pharma value chain from Drug Discovery through to Commercial Manufacturing in a range of organisations including Tripos Discovery Research Ltd, Prosonix Ltd, Dr Reddy's Laboratories Ltd, Johnson Matthey Plc and now Nanoform Finland Plc.

Christian is a Chemist by training and graduated from the University of Leeds in 2003 with a Master of Chemistry Degree. He is also a Fellow of the Royal Society of Chemistry and is passionate about new technologies and scientific innovation and he has a deep technical understanding of Crystallisation Science, Particle Engineering and Respiratory Drug Delivery.

Sanjiv Sharma; Project Leader, Airbus

Sanjiv SHARMA joined Airbus in 1997 as Head of Modelling and Simulation group responsible for delivering design analyses, validation, and verification for the Landing Gear Systems department. Sanjiv is a member of the Airbus Experts Community, with an expertise in Modelling & Simulation. In this role, he leads research relevant to Airbus in his field of applied mathematics; the research projects include industrial supervision of PhD candidates as well as collaborative Post-doctoral partnerships. He is also a member of steering committees for a number of EPSRC Programme Grant projects.

He has over 30 years' experience in Engineering design analysis & Integrated System Engineering Frameworks & Architectures. More recently, Sanjiv has led systems engineering work packages on European (FP7) and UK (ATI) collaborative research projects. He holds BSc in Mechanical Engineering, MSc in Control and Signal processing and a PhD in applied mathematics. Sanjiv is a fellow of the Institute of Mathematics and its Applications and an Associate Member of the Institute of Mechanical Engineers.

Currently, he is the Project Leader for research and deployment of Uncertainty Quantification and Management methods. For the deployment of such techniques, he works with a consortium of European cross-industry companies to develop statistics training materials for experienced, practicing engineers.

Abstracts

Oral Presentations

BIOELECTRONIC SCAFFOLDS: THE FUTURE OF DRUG TESTING

Dannielle Cox-Pridmore - University of Surrey

Around the world, over 100 million animals are used annually for research. However, unforeseen side-effects still arise despite extensive animal testing, which stresses the limitations and differences between human and animal physiology. A prominent side-effect is cardiovascular toxicity, which can be fatal to the patient and contributes to one-third of all safety-related drug withdrawals. A potential solution is the introduction of bioelectronics to create physiologically relevant cardiac tissue that can be experimented on, hence, overcoming our outdated reliance on animals.

This project focuses on the creation of a bioelectronic scaffold that can prove to be a novel platform for cardiac tissue engineering. By being porous and three-dimensional (3D), the structure allows for cell penetration and growth, while encouraging efficient diffusion of oxygen, nutrients, and metabolic waste, therefore producing a more reliable tissue construct. But an incredible advantage of growing cells on a bioelectronic scaffold is that active electronic components are seamlessly integrated into the engineered tissue. Integrated electrodes can promote the correct development of cardiac tissue by electrically stimulating heart cells, which can influence; cell migration, orientation, maturation, and increase contractile behaviour. While highly sensitive biosensors present within the bioelectronics can measure contractility and electrophysiology of the cardiac tissue during clinical testing, giving us a more accurate representation of the human bodies' response to that treatment.

This work promotes the development of a cyborg cardiac construct, that overcomes the limitations seen with animal models during cardiovascular toxicity testing. In the future, an endless supply of reliable tissue can be created to monitor and measure the exact effects of a drug on heart tissue, in turn, reducing the amount of animal testing required.

ENHANCING PROCESS CONTROL IN HIGH VALUE MANUFACTURING WITH PHOSPHOR THERMOMETRY

Fraser McCallum – University of Strathclyde

High value manufacturing industries worldwide are under pressure from global competition and emission targets. Precision temperature monitoring and control has been identified as a point where the metalworking industries can improve process efficiency thus reducing associated production costs while maintaining quality and reducing waste. Metalwork manufacturing utilises infrared imaging and pyrometry to measure temperature, in this environment it is difficult to obtain accurate quantitative surface temperature due unknown or changing surface emissivity's. While it is possible to use thermocouples to provide point measurements, they require alteration of the forging die to operate. An alternative proposed in this current study is phosphor thermometry. Phosphor thermometry uses the temperature dependent luminescent properties of materials bonded to the surface of interest to provide thermometry data, similarly to pyrometery it requires optical access but can operate without knowledge of surface emissivity. A measurement system based on a 2-D lifetime decay mapping was designed to operate with inexpensive camera systems and LED based illumination. Providing a significantly cheaper alternative to high speed camera systems.

ELECTRICAL ENERGY METERING BEYOND STANDARDS REQUIREMENTS

Renán Quijano– University of Strathclyde

During the last few years, the accuracy of static electricity meters has been questioned. Significant metering deviations with respect to a reference meter have been observed at customer premises and laboratory experimental tests results have supported such findings. The root cause of such errors remains unknown, as there are multiple elements that could affect the accuracy of electricity meters. Furthermore, standard-compliant meters exposed to distorted signals may produce either, negligible, positive, or negative relative error depending on the instrument design. In this study, the accuracy of an energy metering Integrated Circuit (IC) is evaluated beyond the limits of the standards requirements employing selected distorted signals. The experimental results indicate a strong relationship between the IC error and two key parameters of the measured waveform: crest factor and phase angle.

INTERLABORATORY EVALUATION OF MALDI AND DESI MSI IN THE CRUK GRAND CHALLENGE PROGRAMME

Melina Kyriazi – University of Surrey

Mass Spectrometry Imaging (MSI) allows the investigation of the spatial distribution of molecules at complex surfaces. Interlaboratory studies are collaborative exercises by laboratories to assess or improve the quality of their measurements. They are important in cancer research in order to evaluate if methods are effective, fit for purpose and transferable between sites. Reproducibility across multiple research centres is the largest obstacle in moving MSI towards routine clinical use.

A preliminary comparison between DESI MSI data acquired in two different labs was completed. Tumour xenografts were implanted in mice, which were treated with two oncology drugs, singly and in combination, or a vehicle control. MSI analysis of serial sections was performed in negative ion mode, using a Waters Xevo G2-XS at Lab A and a Waters Synapt G2-Si at Lab B. Targeted and untargeted analysis was performed to compare the findings.

To understand the differences in metabolite coverage in a more controlled way, key oncometabolites of interest for the CRUK Grand Challenge were chosen to act as standards. These standards were spiked in known concentrations in chemicals, serum, on homogenates and spotted on tissue. Two different approaches of homogenate mimetic preparation were performed: fresh frozen tissue and heat-treated tissue. The hypothesis is that the heat will stop further metabolism of spiked standards on tissue and will increase the accuracy and quality of results.

DATA CLUSTERING FOR FAST IDENTIFICATION OF TWISTED BILAYER GRAPHENE

Tom Vincent – Royal Holloway, University of London

Layering two single-atom-thick layers of graphene with different rotations creates twisted bilayer graphene (TBLG). This exciting material recently caused a commotion when it unexpectedly demonstrated superconductivity. But creating TBLG devices is a laborious process that needs expert scientists. Raman spectroscopy is a powerful, non-destructive tool for imaging numerous properties of 2D materials. But the cost of such information-rich data is that the time spent on analysis can be long. Data clustering, a common machine learning technique, speeds up the analysis of high-dimensional data. It can quickly identify disparate types of material in a single sample, and classify which areas belong to each type. In this work, we apply data clustering to Raman maps of TBLG.

We show that it can be used to successfully identify regions with different twist angle, and we assess the performance of pretrained models for classifying new areas of the same sample. Our results show that data clustering has the potential to enable rapid identification of particular materials, which could significantly speed up the process of prototyping 2D material-based devices.

CHARACTERISING AN EVANESCENT FIELD FOR LARGE FIELD OF VIEW ILLUMINATION IN MESOSCOPIC IMAGING

Shannan Foylan – University of Strathclyde

An evanescent wave is a form of electromagnetic field which does not freely propagate but instead decays exponentially in intensity with distance. For visible light this decay occurs over a characteristic length scale of tens of nanometres and, as such, it is practically challenging to measure the properties of the field. In the field of microscopy, evanescent waves have been exploited improve axial resolution using a technique called Total Internal Reflection Fluorescence (TIRF), named for the method of producing an evanescent field. TIRF microscopy has been used extensively in cell biology to study membrane dynamics, [1], [2], and is often combined with other super-resolution methods to improve both the lateral and axial resolution of an imaging system, [3].

However, extending the field of view (FOV) of a TIRF microscope remains a challenge. The FOV of an optical microscope is intrinsically linked to its' spatial resolution, so imaging a larger population of cells or a larger specimen generally requires forfeit of fine detailed image information. The Mesolens, [4], is a specialist multi-immersion objective lens which overcomes this limitation, with a lateral FOV of 36 mm^2, a sub-cellular lateral resolution of 0.7 µm and a current axial resolution of 7 µm.

We have designed a custom TIRF illuminator for the Mesolens to allow imaging of thousands of cells simultaneously with sub-cellular lateral and axial resolution. We will present details of the TIRF illuminator set up, alongside a simple protocol for measuring the penetration depth of the evanescent field into the sample plane. This protocol, which relies on imaging a fluorescently labelled plano-convex lens specimen with a known geometry, allows measurement of the decay parameter of the evanescent field.

[1] D. Axelrod, J. *Cell Biol.*, vol. 89, no. 1, pp. 141–145, 1981.
[2] J. A. Steyer and W. Almers, *Nat. Rev. Mol. Cell Biol.*, vol. 2, p. 268, 2001.
[3] I. Jayasinghe *et al.*, *Cell Rep.*, vol. 22, no. 2, pp. 557–567, 2018.
[4] G. McConnell, J. Trägårdh, R. Amor, J. Dempster, E. Reid, and W. B. Amos, *Elife*, vol. 5, p. e18659, 2016.

IMPROVING NETWORK VISBILITY FOR BETTER INTERGRATION OF LOW CARBON TECHNOLOGIES INTO LV NETWORKS

Allison Strachan – University of Strathclyde

Historically, the electricity distribution network has been designed on a 'fit and forget' basis, with power being taken from the grid at bulk supply points and carried to final consumers along radial feeders. However, changes in electricity production and use, driven largely by the need to decarbonise energy supplies, mean that 'fit and forget' is no longer adequate. Increased use of low carbon technologies (LCTs) causes significantly increased demands from electric vehicles and the electrification of domestic heating.

To allow distribution networks to respond to these changes, we need to know what impacts the changes are having. However, we don't have sufficient network visibility at present because metering and data collection at low voltage (LV) level is limited.

This research systematically investigates LV distribution networks to determine which parameters, or combinations thereof, provide the best indicators of problems arising on the network as power demand increases.

The relevant network characteristics are then combined with the limited metered data available to provide a prediction of the timescale over which a given network will require upgrading to allow the safe integration of LCTs. Simple 'rules of thumb' are developed that distribution network operators (DNOs) can use when assessing the network impacts of LCTs.

These rules of thumb will allow DNOs to rapidly assess which LV networks are the most vulnerable to increased penetration of electric vehicles and heating, and schedule their upgrading works accordingly. This will ensure that the move to zero-carbon domestic heat and transport is not hindered by the infrastructure failing to keep pace with the growth of LCTs.

NEXT-GENERATION PEROVSKITE PHOTOVOLTAICS: ION-DRIVEN DEGRADATION THROUGH NANOGRAIN FORMATION

Filipe Richheimer – University of Surrey

Achieving the UK's ambitious Net Zero goal for carbon emissions by 2050 requires greatly increased capacity for clean electricity generation. Photovoltaics are an attractive candidate for sustainable and clean energy generation, with emerging photovoltaic technologies offering lower manufacturing costs and higher performance than the current silicon technologies. Recently, organic-inorganic halide perovskites have gained a significant amount of attention due to the possibility of scalable low-temperature deposition, reducing the environmental impact of photovoltaic module fabrication. Moreover, the highest performing perovskite cells reach power conversion efficiencies that are similar to those of monocrystalline silicon devices.

A major hindrance for large scale commercialisation is the poor long-term stability. Perovskite absorbers have shown degradation mechanisms driven by extrinsic (oxygen, moisture) as well as intrinsic (light, voltage bias, current) stressors, some of which lead to irreversible structural and performance changes.

Within a device structure, extrinsic degradation agents can be largely mitigated by effective encapsulation engineering. On the other hand, intrinsic drivers require a detailed understanding of the underlying mechanisms, which subsequently may be counteracted, for example by compositional engineering or passivation.

In the present work we investigate the early formation of degradation products on a triple-cation mixed halide perovskite film. Using advanced atomic force microscopy modes in dry nitrogen environment, we observe nucleation of nanometre-scale grains on the perovskite film under operating conditions and extract dynamic charge transport information to help understand the degradation process. We identify A-site cation volatility enhanced by the local electrostatic environment as a stressor impacting operational and long-term stability. These findings provide important insights with sub-grain dimensional resolution on the impact of local space-charge formation impacting structural stability during operation.

3D MODELLING OF METHANE ISOTOPE RATIOS

Alice Drinkwater – University of Edinburgh

The relative importance of various methane source and sinks are continuously evolving as a result of changing human behaviour (such as changing agricultural practices and increasing fossil fuel emissions). Important sources of methane include natural sources such as wetlands, as well as anthropogenic sources such as oil and gas emissions and agriculture, but how the relative importance of these sources have evolved over time is poorly understood.

The isotopic composition of methane (this presentation focusses specifically on bulk isotope ratios d13C and dD), has been shown to provide constraints on source apportionment, with different sources having characteristic isotope ratios, or 'source signatures'. Such analysis can lead to a better understanding of varying magnitude of sources and sinks over time. This in turn can resolve the evolution of anthropogenic sources, leading to better understanding of human-caused climate change.

However, source signatures may themselves vary over time, and have inherent uncertainties. As such, I am using the GEOS-Chem 3D chemical transport model to understand the spatial and temporal isotopic behaviour of atmospheric methane on a global scale. I am using in-situ datasets and emissions inventories to perform inversions for total CH_4 emissions, d13C and dD sectoral source signatures globally over the years 2004-17. The main study aims are to reduce uncertainty in source signature estimation and emissions estimates over recent years, leading to a better understanding of how atmospheric methane is changing over time.

ACTIVE PHOTONIC THERMOMETRY

Anoma Yamsiri – University of Surrey

Various thermometry techniques have been developed to measure temperatures with uncertainties from 10 mK to 100mK. It is integrated in many areas from domestic settings, e.g. a cooker to monitoring the temperature of medical devices, spacecraft, and even nuclear waste inventory. Existing temperature sensors or thermometers are mainly based on expansion of a liquid medium, changes of electrical resistance, the thermoelectric effect or thermal radiation. This new approach to measure temperature using light, exploits the potential of modern photonics in thermometry to reduce the production cost as well as increase convenience of usage and tolerance to environmental variation.

This paper describes research on new approaches to measure temperature using light. The research involves using active semiconductors such as GaAs and InP to form resonant photonic structures with embedded optical gain media. The refractive indices of the semiconductor materials change accordingly with the temperature ranges in which the structures are used in different systems. Thermally induced shifts in refractive index of the structure lead to a precise change in wavelength of the resonance optical structures providing an effective scientific and commercial applications for measuring the temperature variation. This approach exploits the exceptional capability and volume production potential of modern photonics to reduce the production cost and increase convenience of usage. Scalability and the small size of photonic components potentially allow the thermometer to be integrated onto existing instruments. An advantage of using photonic systems also allows the thermometer becomes robust against electromagnetic interference and tolerance to environmental variation.

In an initial design, ring resonators, heterostructures and their characteristics such as effective refractive index, free spectral range (FSR), energy distribution and loss are studied using finite-difference time-domain (FDTD) method. The analyses of temperature dependent of the ring resonators, plan for fabrication and measurement of the device will be presented.

A HOMODYNE DISPLACEMENT MEASURING INTERFEROMETER WITH REAL TIME NON-LINEARITY CONNECTION

Angus Bridges – Cranfield University

Traceable displacement measurement is required for a variety of industrial and research tasks, with traceability to the SI standard needed for meaningful comparisons to be made. Instruments capable of traceable measurement at the nanoscale often rely ultimately upon optical interferometry for traceability. Improving the sub-nanometre performance of optical interferometers is therefore desirable as the use of nanotechnology becomes widespread.

Displacement measuring interferometers suffer from non-linearities in the measured displacement that limit the achievable measurement uncertainty for microscopic displacements. Whilst a range of non-linearity correction techniques have been proposed in the literature, correcting for non-linearities in displacement measurements covering a range of less than one optical fringe remains a challenge, particularly in real time.

A novel active non-linearity correction methodology is proposed here that allows for real time compensation of errors in the gain, DC offset and quadrature phase, along with a partial correction for non-linearities introduced by unwanted multiple reflections. The optical powers returned by the measurement and reference arms of the interferometer are monitored separately, and, alongside a self-calibration process, this allows the gain ratio and DC offset errors to be minimised independently of the optical properties of the interferometer and the detector gains. Quadrature errors are transformed to gain ratio errors by taking sums and differences of the quadrature signals, permitting an ellipse fit with two degrees of freedom, rather than the usual five, to be employed as a final correction step. Reducing the degrees of freedom in the fitting process permits small portions of an ellipse to be fitted successfully, allowing the correction methodology to be applied to sub-fringe displacements. The coefficients of this restricted ellipse fit may be found in terms of sums of powers of the quadrature signals, allowing the correction to be implemented in real time on a FPGA or microprocessor-based system.

PREDICTING FAILURE LOCATION IN DEVICE EMBEDDED SUBSTRATES TO ENABLE THE NEXT GENERATION OF MINIATURISATION

Dan Flintoft – University of Surrey

Device embedded substrates (DES) are printed circuit boards in which the components are assembled within the layers of the substrate itself, as opposed to being on the surface as they are traditionally. In doing this the circuit density is greatly increased and allows for a significant reduction in the board's footprint, as well as proven reliability improvements. This enables designers to further miniaturise their products.

However, DES are not yet widely adopted as a standard manufacturing process for electronics. This is attributed to several reasons, firstly the manufacturing process has not been standardised, meaning that there are multiple approaches, each with varying results. Secondly, there is insufficient research into the unique failure mechanisms DES can or could experience when compared to their surface mount equivalents.

This work focusses on the mentioned issues through a combination of simulation and experimental verification. By exploring design variations within COMSOL which can minimise the stress at predicted failure locations during reliability testing. Optimised design parameters can then be output, allowing creation of DES with minimised risk of failure. Verification of the predicted failure location will later be shown through experimental validation of the simulations.

PANCREATIC DUCTAL ADENOCARCINOMA TISSUE ENGINEERING TO SUPPORT HYPOXIC RADIO-RESISTANCE PROFILING

Gabrielle Wishart – University of Surrey

The interdisciplinary field of tissue engineering is emerging to bridge the gap between simplistic 2D cell culture models and complex xenografts, more readily emulating biophysical-chemical and mechanical in vivo properties of tumours to improve pre-clinical treatment screening of anticancer therapeutics [1]. Moreover, polymeric scaffolds act as building blocks to replicate elements of the tumour microenvironment (TME) such as, the addition of extra cellular matrix proteins to support growth and adhesion, co-culture to replicate heterogeneous cell populations and hypoxic culture [1-3]. The TME is a key player in patient response to radiotherapy. More specifically, tumour hypoxia is a hallmark of pancreatic ductal adenocarcinoma (PDAC), associated with metastasis, decreased overall survival and radio-resistance [1-4]. Despite this, preclinical radiation screening takes place in 2D normoxic cell culture. Tissue engineering allows the re-modelling of the hypoxic TME for more accurate radio-resistance profiling. Here we develop a 3D hypoxic polymeric scaffold for long term culture and treatment screening of the PDAC cell line PANC-1.

Fabrication of polymeric 3D scaffolds employed the Thermally Induced Phase Separation method [4]. PANC-1 cells were seeded at 0.5x106 and cultured for 3 weeks before being placed at 5% oxygen in a hypoxic chamber. Radiotherapy exposures were performed using an orthovoltage x-ray unit at the Royal Surrey County Hospital. Scanning electron microscopy and confocal laser Scanning microscopy (CLSM) enabled scaffold characterization, allowing analysis of cellular organisation and viability. More specially, live/dead analysis and hypoxic biomarkers permit quantification of radio-resistance.

This research provides a platform for studying the complex and hypoxic PDAC TME. Our data show for the first time, a 3D polymeric scaffold supporting long term hypoxic PDAC cell culture. This system enables hypoxia-associated radio-resistance profiling of PDAC. Future work will investigate static magnetic field radiotherapy combinations towards image guided radiotherapy research.

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TOWARDS WAFER SCALE MINORITY CARRIER LIFETIME MAPPING USING A COMPRESSIVE SENSING APPROACH

Aidas Baltušis – University of Surrey

Semiconductors are used in a diverse range of applications in electronics and photonics. For quality control (QC) of grown semiconductor wafers, it is crucial to know the charge carrier lifetime, which is typically measured by acquiring time-resolved photoluminescence (TRPL) using a time-correlated single photon counting (TCSPC) method. However, the single photon detector used in TCSPC is only suitable for point-by-point measurements. Therefore, commercial systems raster-scan the wafers to build-up a carrier lifetime map to highlight any areas of interest. This is a time consuming and problematic process, which needs to be improved upon in order to satisfy the growing volumes in industry, e.g. for solar panel or laser production. Using the mathematical theory of compressive sensing (CS) combined with advances in computational optimisation algorithms, measurements below the Shannon-Nyquist sampling limit can be acquired. We propose a new technique of TRPL mapping using CS TCSPC. The proposed method eliminates the need for mechanical movements of components such as translation stages. Instead, the spatial information is retrieved using a digital micromirror device (DMD). A series of patterns are projected onto the sample and the resulting TRPL of each pattern is measured. Using convex optimisation algorithms, the TRPL map is constructed. The approach is verified using a Python computational model simulating TCSPC measurement and reconstruction of a 64x64 pixel image. The model shows a structural similarity index of 0.94 between the sample and reconstructed image with only 20% of the patterns used. Based on the parameters used in the simulation, an equivalent measurement would take 13 minutes to run. The proposed method of quantifying the quality of semiconductor materials and devices will have an impact on reducing production time and costs, ultimately leading to cheaper LEDs, sensors, photovoltaic devices, and other consumer electronics. This new approach will lead to orders of magnitude increase in mapping speeds, and significant signal amplification, which will allow in-line integration and reduce the cost of advanced semiconductor manufacturing.

UNSUPERVISED LEARNING WITH GAUSSIAN PROCESSES AND STOCHASTIC DIFFERENTIAL EQUATIONS

David Lopes Fernandes – Bath University

Recently, there has been increased interest in using differential equation systems in machine learning models. The NeuralODE approach uses neural networks to model the dynamics of an ordinary differential equation system. More recent work replaced the neural network with a Gaussian process (GP) to specify a stochastic differential equation (SDE) with the aim of accounting for uncertainty. While the NeuralODE model was applied to both supervised and unsupervised problems, the GP approach only has supervised applications in low dimensions. A critical issue is the difficulty of constructing a GP in a high-dimensional space to determine the SDE for practical problems. Our work proposes to fill this gap using General Itô's formula to bridge low to high dimensional spaces.

With this approach, it is possible to relate two stochastic processes in different dimensions through a deterministic mapping. In our work, the lower dimensional process is modelled using a GP, and several mappings are tried, from simple linear combinations to more complex ones, like neural networks.
From observations of data in the higher dimensional space, we can learn a latent stochastic process underlying the data, and a corresponding mapping. The way the data points are shown to the model is flexible: if the data are time series, only points at certain times can be provided; if not, then the model can try to build a stochastic process that can reconstruct the data while finding a lower dimensional representation.

ULTRA-PRECISION MACHINING OF SILICON LAMELLAE WITH MINIMAL SUB SURFACE DAMAGE

Declan Cotter – University of Strathclyde

The aim of this project is to optimise the grinding process of silicon lamella for the manufacture of x-ray interferometers. In 2019 the Mise en Pratique for the metre was revised, adding a new route to traceability for nanoscale length measurements via the lattice parameter of silicon. One realisation of this traceability route is through an x-ray interferometer, which can be regarded as a translation stage or ruler where the graduations are based on the lattice spacing of crystallographic planes from which x-rays have been diffracted; in this case the (220) planes in silicon with a spacing of 192 pm.

An x-ray interferometer requires thin (10 mm x 15 mm x ~0.8 mm) vertical lamella to be machined from a single crystal of silicon. They must be defect free as any damage to the silicon lattice adversely affects the x-ray fringes. The grinding process used for the lamella production causes sub surface damage that includes microcracks and plastic flow of the silicon all of which must be subsequently removed using either wet or dry (plasma) etching. The grinding process for the lamella production has been modelled theoretically to predict the optimum conditions for silicon machining i.e. with minimum damage. A series of experiments has been designed: silicon will be ground using different grinding parameters. For each set of cuts, debris from the machining process will be captured, separated from the machining coolant using dialysis and measured in the scanning electron microscope. This, together with wedge polishing of the cut pieces, will allow the sub surface damage as a function of the grinding process to be quantified and related to the models of the process.

This research forms part of a larger project leading to the development of a new x-ray interferometers to support nano and sub-nano scale dimensional metrology.

SECURING DIGITAL CALIBRATION TRACEABILITY IN SAFETY-CRITICAL IOT

Ryan Shah – University of Strathclyde

Secure sensor calibration constitutes a foundational step that underpins operational safety in the Industrial Internet of Things. While much attention has been given to IoT security such as the use of TLS to secure sensed data, little thought has been given to securing the calibration infrastructure itself.

Currently traceability is achieved via manual verification using paper-based datasheets which is both time consuming and insecure. For instance, when the calibration status of parent devices is revoked as mistakes or mischance is detected, calibrated devices are not updated until the next calibration cycle, leaving much of the calibration parameters invalid.

Aside from error, any party within the calibration infrastructure can maliciously introduce errors since the current paper-based system lacks authentication as well as non-repudiation. To this, we propose a novel resilient architecture for the calibration infrastructure, where the calibration status of sensor elements can be verified on-the-fly to the root of trust (NMIs) preserving the properties of authentication and non-repudiation. We propose a proof-of-concept implementation based on smart contracts on the Ethereum blockchain network. Our evaluation shows that Ethereum is likely to address the protection requirements of traceable measurements.

INFERRING LONDON'S METHANE EMISSIONS FROM ATMOSPHERIC MEASUREMENTS

Daniel Hoare – University of Bristol

Major cities such as London are emission hotspots for greenhouse gases such as carbon dioxide and methane, but they also have the political power to enact local changes to reduce emissions. To ensure that emission reduction policies are successful, policy makers require accurate knowledge of how emissions change over time.

Annual emission inventories are frequently used to report greenhouse gas emissions. These inventories are made by compiling socioeconomic data with corresponding emission rates to estimate the amount of greenhouse gases produced. It is considered good practice to accompany inventories with top-down methods. These top-down methods seek to improve inventory estimates by incorporating atmospheric measurements and models. By measuring the gases in the atmosphere, top-down methods are able to identify unreported emissions and under/over-estimates in the inventory.

In the London Greenhouse Gas Project, we expand upon the UK's existing national top-down measurement infrastructure by adding a London measurement network. A series of atmospheric concentration instruments are being installed across the city and will be used to estimate London's emissions. A medium-density urban network provides challenges in instrument calibration and siting, as well as the development of new modelling approaches to link the measurements to policy-relevant emissions estimates. In this poster we present the initial progress and results from the project.

TOWARDS TRACEABLE THERMAL IMAGING OF NUCLEAR WASTE CONTAINERS

Jamie McMillan – University of Surrey

Safe management of nuclear waste in storage necessitates robust and traceable characterisation methods to monitor package integrity, composition of gaseous emission and internal activity. Deployment of quantitative thermal imaging within container stores would enable insight of internal container activity (where temperature is indirectly related to activity) as well as characterising the external surface conditions of each package. Laboratory measurements identifying and approaching the primary measurement challenges to the deployment of this technology in industry are presented and a clear route to future system integration is provided.

To characterise the traceably calibrated cooled medium-wave infrared thermal imager and its ability to identify surface defects (scratches, dents, thinning and pitting), a simulant plate comprising a selection of these defects was designed. Measurements using the thermal imager of the simulant plate at temperatures up to 200 C demonstrated the potential to isolate a subset of these artefacts. The thermal imager and this database of defects was then applied to two types of waste containers and a range of existing defects were identified. These measurements were supported through thermal modelling of the systems and dimensional verification of the defect geometry.

ASSESSING LONDON'S METHANE EMISSIONS AND SOURCES THROUGH HIGH-FREQUENCY MEASUREMENTS AND SIMULATIONS

Eric Saboya – Imperial College, London

Over half the worldwide population currently live in urban areas. These areas account for a considerable portion of anthropogenic greenhouse gas emissions. Signatories of the 2015 UNFCCC Paris Agreement are required to report their annual emissions as well as to verify and improve the accuracy of their emissions estimates through independent methods. Atmospheric measurements from the top of tall structures, such as buildings, are one approach that can be used to improve the methodology and accuracy of bottom-up emissions estimates at a city-scale.

High-frequency, in situ measurements of atmospheric methane concentrations and δ13CH4 have been made from the top of the Physics building at Imperial College London since early 2018. A subset of these data was analysed to determine the dominant sources across central London. We found a predominance of natural gas methane, comprising of 33-40 % of source values, and contributions from the waste sector forming 19-24 % of the source values.

Three sets of back-trajectories differing in horizontal spatial resolution were produced with the UK Met. Office's atmospheric transport model, NAME. NAME was used to transport anthropogenic emissions from the UK's national inventory and the global emissions database to generate four sets of simulated concentrations and δ13CH4 values. The highest resolution back-trajectories combined with the UK's national inventory formed the most accurate set of simulations, which underestimated the measured concentrations by ~32 %. The waste sector was found to be the dominant source of methane in all sets of simulations. Natural gas emissions were found to be underestimated in both inventories when compared to these measurements.


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"A PGI mentor can help you to get the most out of your Doctoral Research period, boosting your skills portfolio and transferable experience"

Lewis Hill

PGI researcher, University of Strathclyde

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The Organising Committee would like to thank you for attending and participating in the 5^{th} PGI Conference. We hope to see you in person next year!

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