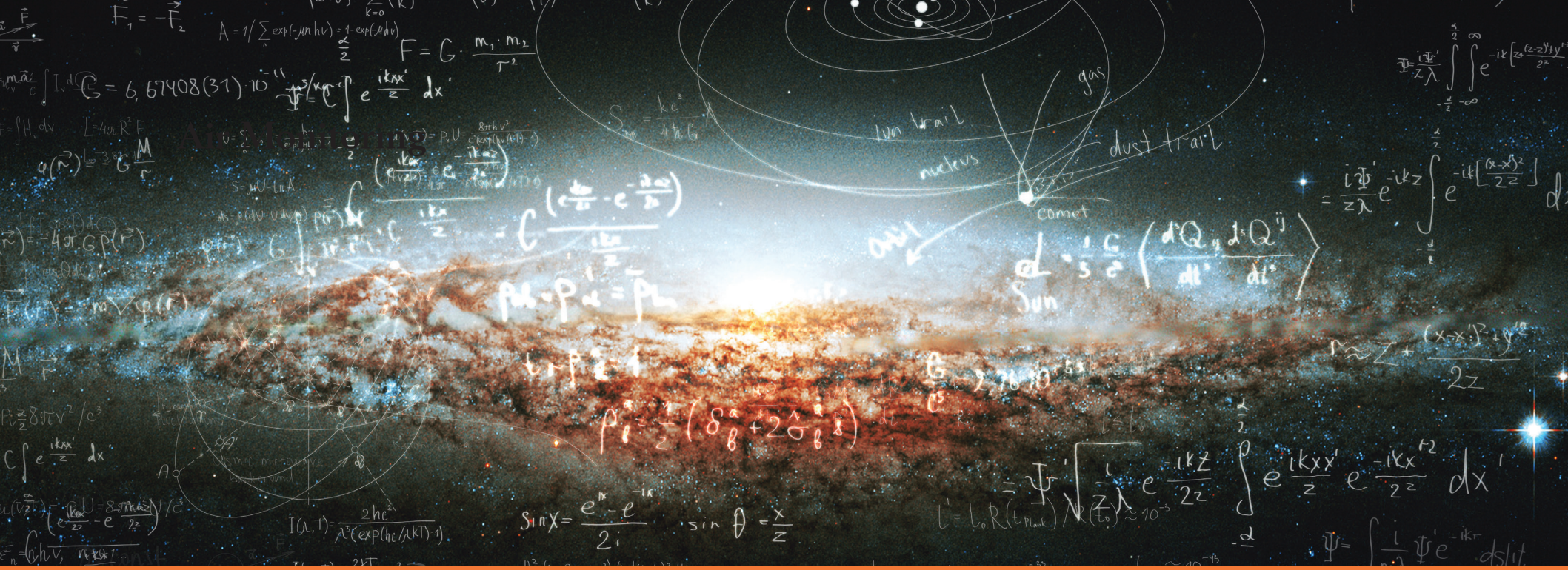


SPACE SCIENCE USED TO ADDRESS GLOBAL AIR POLLUTION CHALLENGES

Space science isn't just about travelling beyond our atmosphere, or exploring deep space. The technological advances that have come from space programmes, satellite development and astrophysics have day to day benefits back here on Earth. MRI scanners, miniaturised computers, even Velcro all come from the realms of space science. So what other benefits could be gained from working with scientists, researchers and engineers in these areas? The UK's Science and Technology Facilities Council (STFC) has an exciting array of capabilities ranging from large analytical facilities to miniaturised sensors, with a huge amount of data storage, analysis and modelling capacity along the way. The STFC Air Quality Network (SAQN) is exploring how these capabilities might be used to address the global challenge of air pollution, a problem that causes 4.2 million deaths per year[1].

What does SAQN do?

Our overarching aim is to bring together research, industry and policy to address air quality challenges, improving measurement technologies, maximising use of data, optimising models and exploring chemical reactions. We need industry and policy to help define exactly what the challenges are, and research to find the solutions. SAQN can connect industry with researchers from across STFC and the wider air quality community, exploring opportunities to apply their skills and expertise to address the challenges you face around air pollution. Our key aims are to:

- Engage with industry and policy
- Initiate lasting collaborations
- Increase awareness of STFC capabilities

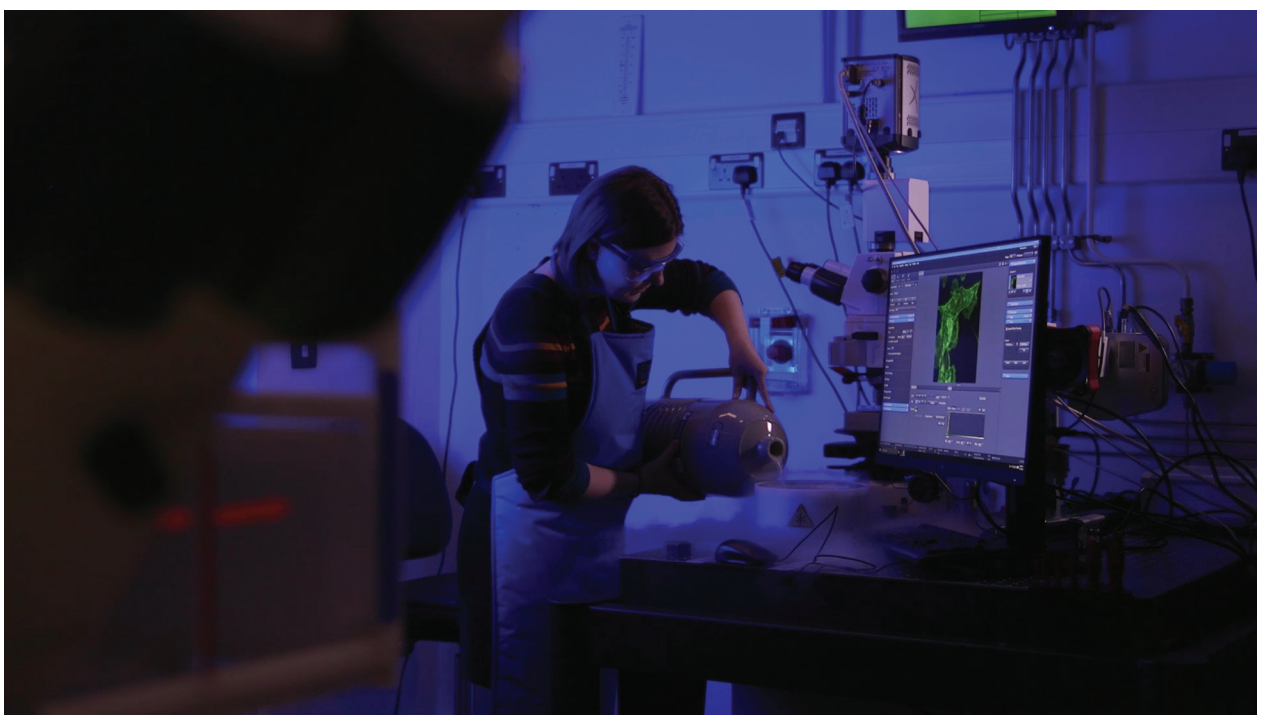
Our activities to achieve this include:

- Network website
- Monthly newsletters, including our activity and wider news from the community
- Targeted meetings on relevant topics
- Funding research into new ways of using STFC capabilities
- Travel funds for meetings and events with STFC scientists
- Matchmaking between community members

How can you get involved?

SAQN is keen to engage with industry, both to inform the activity of the network and to support the potential commercialisation of some of the technologies being developed. You are warmly invited to get involved in one of the following ways:

- Join the network: sign up for free on the SAQN website and receive a monthly newsletter with all the latest information
- Attend an online networking session: held regularly online, these informal sessions offer the chance to connect with STFC scientists and air quality researchers, and members can give a 60 second pitch about their area of interest to spark conversations



Computation Fluid Dynamics are used to plot carbon dioxide distribution in a room © STFC

- Come to the SAQN Annual Meeting: held in York 18-19 May 2022, the annual meeting will feature a session on industry challenges.
- Apply for a Travel Grant: SAQN can fund travel and accommodation for network members to visit STFC facilities and explore collaboration opportunities
- Explore the SAQN website: this includes details of the Scoping Studies funded so far, as well as more information about STFC. If you have specific ideas you think STFC could help with, contact SAQN directly for matchmaking.

What can the STFC do?

STFC has a dazzling array of capabilities in different areas. Their core purpose is to carry out frontier research in particle and nuclear physics, space science and High Performance Computing. STFC have laboratories and sites across the country, from the famous Rutherford Appleton Laboratory in Oxfordshire, to the bottom of a deep mine in North Yorkshire, where scientists search for dark matter. Their Science and Innovation Campus fosters collaborations between industry and academia, with co-location of industry with research centres. Businesses are supported to reach their full potential through Innovation Clusters, where startups,

Aerial view of RAL Space at the Rutherford Appleton Laboratory © STFC

scale ups and sector leader companies sit alongside leading academic institutions in a thriving community. STFC are also a research funder, and award grants for new research ideas and to support commercialisation of new technologies.

STFC's capabilities can be broadly divided into three categories: Large Analytical Facilities, High-Performance Computing and Instrumentation Development.

Large Analytical Facilities

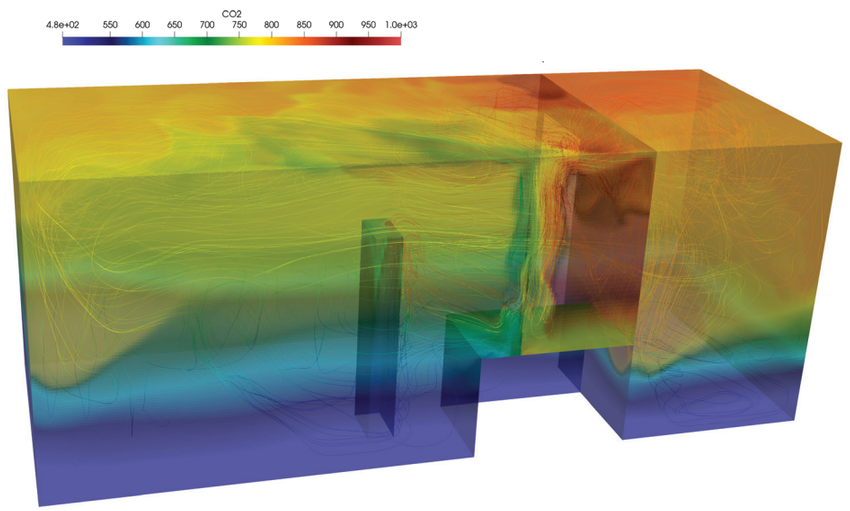
These include the Diamond Light Source, which acts like a giant microscope to examine materials at atomic and molecular scales. As its name suggests, Diamond is very bright and can see very weak signals. The ISIS Neutron and Muon Source works in a similar way, but is better suited to studying light at the atomic scale. Finally, the Central Laser Facility has a suite of instruments, including particle accelerators that can probe chemical reactions as they happen. Example applications for this could be to examine chemical reactions in lung fluids or on atmospheric particles. The Central Laser Facility's instruments can investigate biochemical and biophysical processes, and can also pinpoint individual particles for study.

SAQN have one funded project making use of the Large Analytical Facilities; scientists from UKHSA (formerly Public Health England) are using both the Central Laser Facility and ISIS Neutron and Muon Source to explore how nanoparticles behave at the Blood Brain Barrier, improving our understanding of the health impacts of air pollution. Two more SAQN funded projects have identified potential applications of the techniques available at these facilities to investigate the effects of wildfires on human health and climate change by studying biomass burning aerosol and to learn more about the reactivity of Persistent Organic Particles (POPs).

High-Performance Computing

The Hartree Centre in Cheshire enables industry access to STFC's world-class High Performing Computing capabilities, and also to their software development skills. It includes the largest supercomputer in the world dedicated to software development, and is specifically focused around industry applications. The Centre for Environmental Data Analysis holds the largest amount of environmental data, and through JASMIN, allow researchers to work collaboratively to analyse large datasets and to host models and data in one place. Among the many areas of expertise, those most relevant to air quality research are:

- Computational chemistry
- Computational engineering
- Computational fluid dynamics
- Model coupling
- Data integration and visualisation
- Machine learning
- AI technologies for data analysis
- Software development and engineering
- Petascale data storage



Visualisation of CO_2 © STFC

- Satellite measurements
- Instrumentation and data

SAQN-funded Scoping Studies have explored the applications of these techniques to air quality in a number of ways. One team used Computational Fluid Dynamic modelling to map indoor air quality, and another has combined satellite data with ground based measurements to improve monitoring of ammonia emissions. Machine learning has been used to speed up real-time air quality predictions in a project that has also drawn on satellite data.

Instrumentation development

STFC have developed numerous new instruments for use in space science and satellite measurements, which require novel technologies that can work in harsh environments, need to be compact, lightweight, low power, autonomous… in short, all things that make them ideal for field deployment in air quality research.

Many SAQN-funded projects to date have taken advantage of this expertise, including the development of new miniaturised sensors that can be mounted on an unmanned aerial vehicle (UAV) for deployment in volcanic plumes. The miniaturised sensors will be further developed in another project, which will produce a next generation air quality sensor. This aims to be smaller, cheaper and more accurate than its predecessor, and has significant commercialisation potential. SAQN have also funded a project looking at fluxes and source apportionment, building on pre-existing sensor technology and developing a new ammonia sensor. And the AiRefUnits project also makes use of the miniaturisation capabilities of STFC to develop a low-cost reference unit to calibrate measurements from other sensors in low-resource regions.

These are just some examples of how STFC capabilities could be applied to air pollution research. SAQN is keen to connect more researchers with challenge owners to identify additional areas for STFC capabilities to drive air quality research forward.

References

1. https://www.who.int/health-topics/air-pollution#tab=tab_1

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