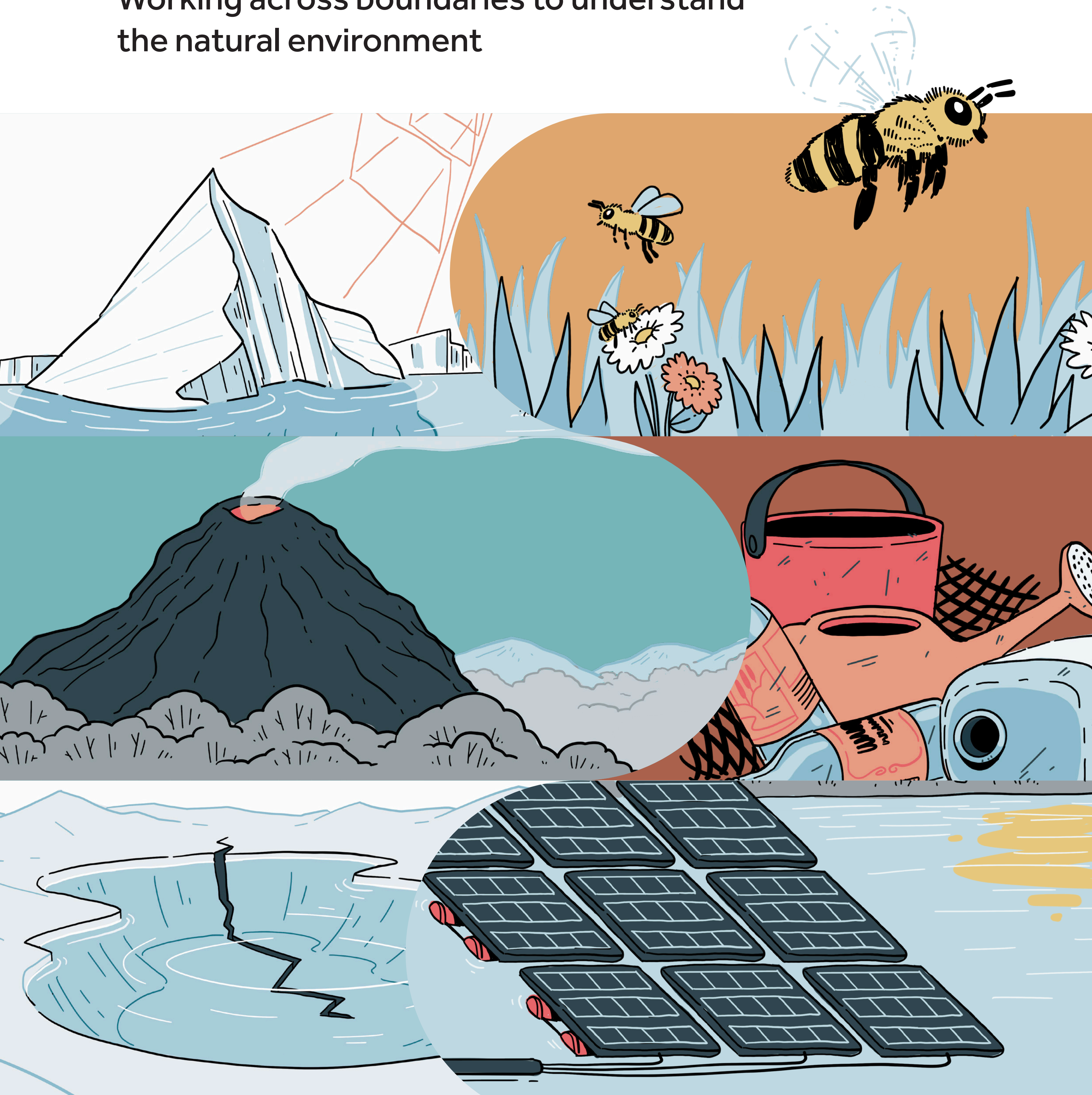
NERC Cross-Disciplinary Discovery Science at Lancaster University

Working across boundaries to understand the natural environment



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Lancaster Environment Centre | Lancaster University | Centre for Global Eco-Innovation | UKRI Natural Environment Research Council

Introduction

From the deepest oceans to mountain tops, from the edges of the atmosphere to your backyard, as environmental scientists, the whole planet fascinates us.

The complexity of the environmental world is magnificent - with interconnecting processes from microscopic microbiota to the shifting of the Earth's crust. Change can occur in the fraction of a second or quietly over centuries. But our relationship with the environment has intensified, it is fraught and complex; just as humanity is moulded by environmental processes, we continue to shape the natural world at an alarming rate.

To protect the natural environment for future generations, we must accelerate and intensify our understanding of the natural world. How will our planet respond to human-driven crises and change in climate, land use, and the impacts associated with synthetic waste? How can we sustain and restore our planet? How can we adapt and evolve to thrive in a changed and less predictable environment in ways that are more in harmony with its other inhabitants?

The NERC Cross-Disciplinary Discovery Science fund supports researchers to work across traditional disciplinary boundaries to develop innovative and high-reward projects to break the boundaries of our current knowledge of the environment.

At Lancaster University, we have a long history of innovative, collaborative environmental science. Recognising the complexity of environmental issues and the need for close working across disciplines, we were one of the first universities in the world to establish a Department of Environmental Science and to offer Ecology as a full degree subject.

In 2007, we brought together Geography, Environmental Sciences and Biological Sciences to create **Lancaster Environment Centre (LEC)**, which is now one of the largest and most impactful centres of Environmental research in the world. Since then, we have embedded environment across many of our cross-cutting institutes and initiatives, such as the **Centre for Global Eco-innovation (CGE)**.

With the support of the NERC Cross-Disciplinary Discovery Science fund, we challenged colleagues from across all disciplines, including the natural and physical sciences, social science and arts and humanities, to partner with our environmental scientists to help address the most pressing research questions about the natural environment. We have funded seven ambitious small projects that forge new and exciting collaborations.

Our new cross-disciplinary research teams are exploring diverse parts of the natural environment from microbes and soil to volcanoes and ice. Critically, they are harnessing knowledge using a diverse set of interdisciplinary research approaches including:

- **Economics and management research**
- **Data science and artificial intelligence**
- **Engineering and material sciences**
- **New imaging techniques borrowed from astrophysics**
- **Gut microbiology**

We are delighted to share with you the new questions and collaborations that have been generated across Lancaster University.

We are at the beginning of the journey - we invite you to connect with project leaders and join us in our discovery to better understand and protect the planet.

Montserrat: where a volcano, soils, water, ecology, and reefs meet

Hugh Tuffen, Jan Bebbington, Nick Graham, Phil Haygarth, Christina Hicks, John Quinton, Carly Stevens

The challenge

Montserrat is a Caribbean island with huge challenges related to population loss, sustainability, and resilience following a devastating volcanic eruption. The volcano destroyed livelihoods, agricultural land, coral reefs, and fisheries. How can effective management help the community and ecosystems recover in a sustainable way?

The big questions

- *How do Montserrat's diverse ecosystems, environments, and societal needs intersect and interact (volcano, soils, agriculture, coast, sediments, reef, and fisheries)?*
- *Which solutions best support a sustainable environment and society?*

The research

We carried out a preliminary analysis of sediment, agriculture, and reef impacts in Montserrat.

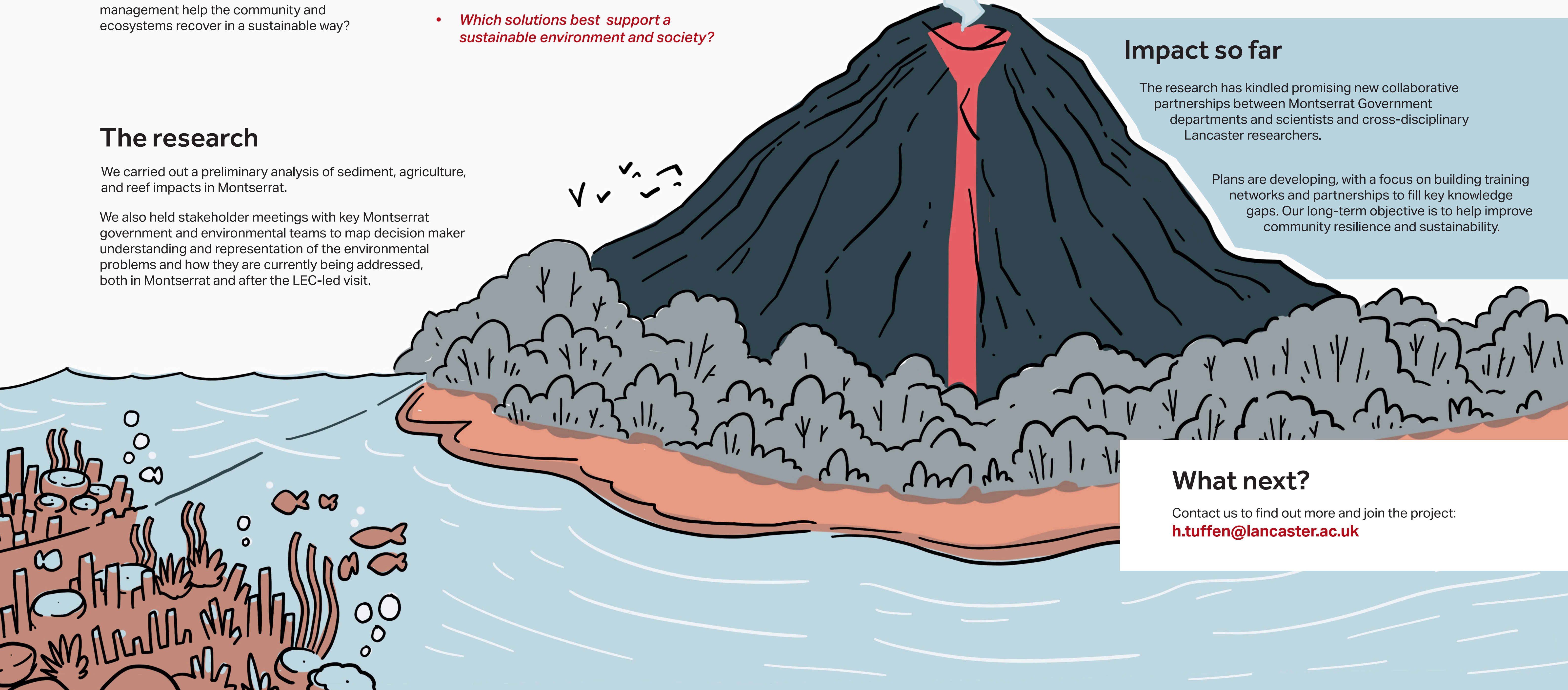
We also held stakeholder meetings with key Montserrat government and environmental teams to map decision maker understanding and representation of the environmental problems and how they are currently being addressed, both in Montserrat and after the LEC-led visit.

Findings so far

A working hypothesis is that the reefs are being damaged by volcanic ash, but the transport of sediment and its impacts on reefs is poorly understood.

The source of agricultural problems on the island includes soil erosion, reduced available land due to the volcanic exclusion zone, and a lack of willing farm workers.

Pathways to sustainable solutions are currently blocked by key knowledge gaps and there is strong potential to develop new partnerships.



Impact so far

The research has kindled promising new collaborative partnerships between Montserrat Government departments and scientists and cross-disciplinary Lancaster researchers.

Plans are developing, with a focus on building training networks and partnerships to fill key knowledge gaps. Our long-term objective is to help improve community resilience and sustainability.

What next?

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Detecting icebergs like stars

John Stott and Matthew Chan

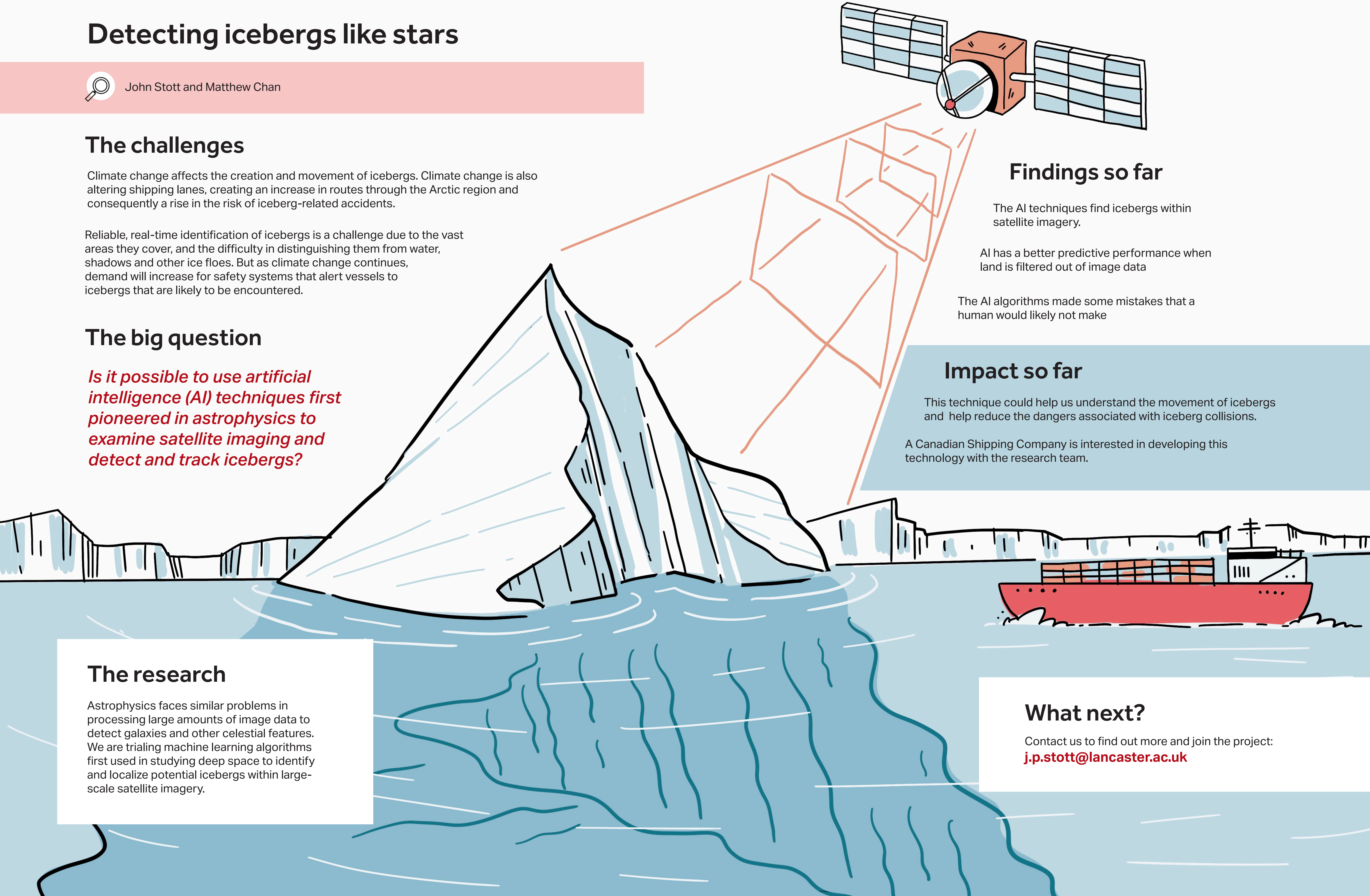
The challenges

Climate change affects the creation and movement of icebergs. Climate change is also altering shipping lanes, creating an increase in routes through the Arctic region and consequently a rise in the risk of iceberg-related accidents.

Reliable, real-time identification of icebergs is a challenge due to the vast areas they cover, and the difficulty in distinguishing them from water, shadows and other ice floes. But as climate change continues, demand will increase for safety systems that alert vessels to icebergs that are likely to be encountered.

The big question

Is it possible to use artificial intelligence (AI) techniques first pioneered in astrophysics to examine satellite imaging and detect and track icebergs?



The research

Astrophysics faces similar problems in processing large amounts of image data to detect galaxies and other celestial features. We are trialing machine learning algorithms first used in studying deep space to identify and localize potential icebergs within large-scale satellite imagery.

Findings so far

The AI techniques find icebergs within satellite imagery.

AI has a better predictive performance when land is filtered out of image data

The AI algorithms made some mistakes that a human would likely not make

Impact so far

This technique could help us understand the movement of icebergs and help reduce the dangers associated with iceberg collisions.

A Canadian Shipping Company is interested in developing this technology with the research team.

What next?

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Time is running out to understand supraglacial lakes in Greenland

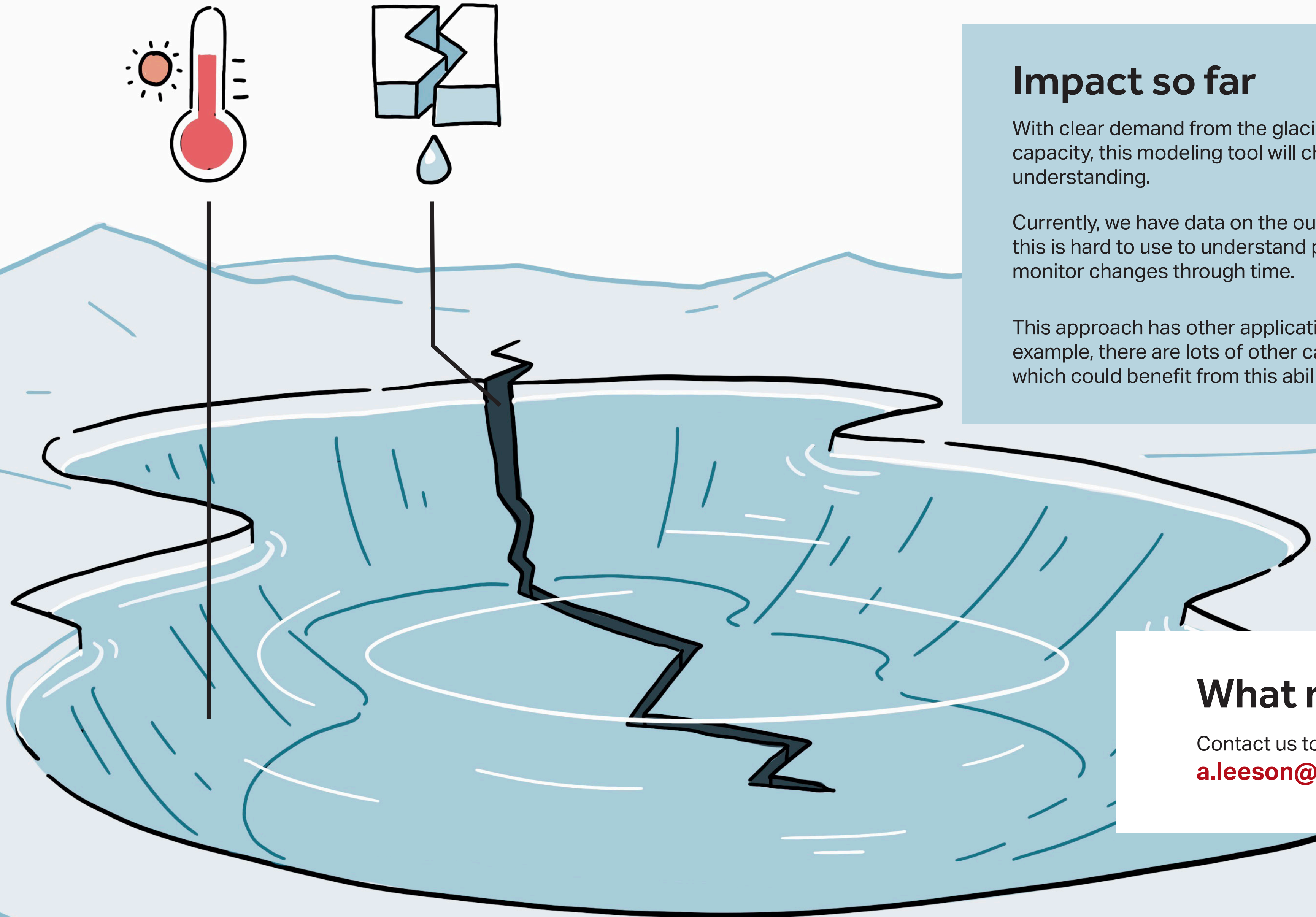
Amber Leeson, Diarmuid Corr, Israel Martinez Hernandez, Mal McMillan, David Parkes

The challenge

Ice caps are melting. Surface meltwater on the Greenland ice sheet is a seasonal response to summer temperatures creating supraglacial lakes, but the amount of meltwater could be drastically changing. We need better ways to monitor lakes created by meltwater as they feed back into changes in the ice sheet - lake water can drain through cracks in the ice and affect the flow speed of the ice. Whilst we have data on the outlines of surface lakes from satellite imagery this doesn't give us enough depth of understanding.

The big question

Can we make better use of statistical advances to increase understanding of the fate of our supraglacial lakes in space and time?



The research

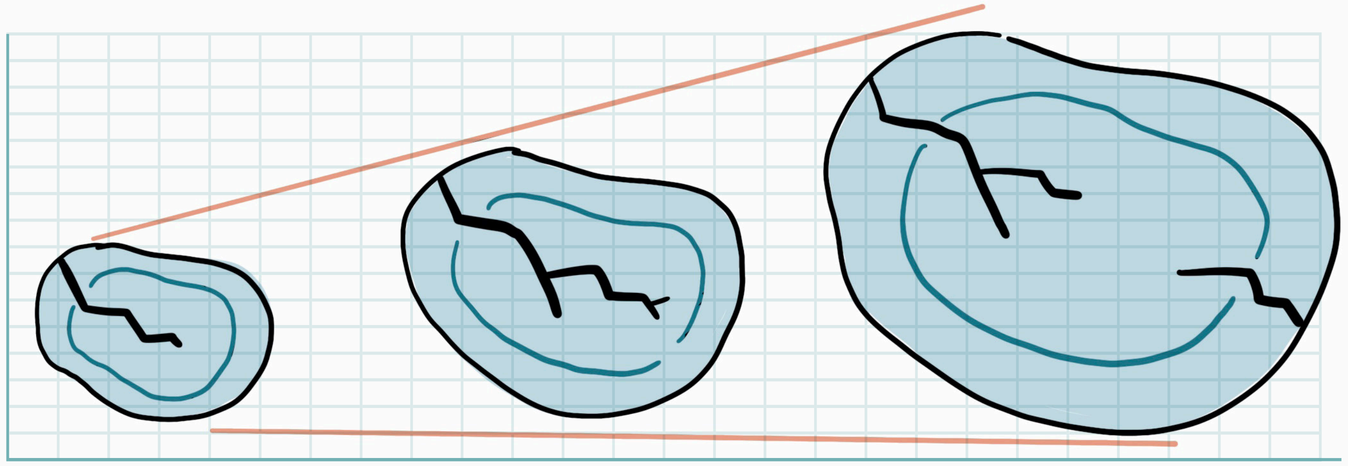
Through a new collaboration between glaciologists and statisticians we are developing a novel approach to extracting meaning from satellite imagery of supraglacial lakes.

In contrast to traditional methods that generate many thousands of independent features that are hard to interpret, our new approach inspired by functional time series analysis can help us better identify lakes and monitor their continuous properties like surface temperature using gridded models.

This novel statistical approach exploits the fact that we know lakes tend to appear close to other lakes and that their changes through time are correlated.

Findings so far

Preliminary studies are complete using a regular gridded principal component analysis (a simpler statistical model), this work demonstrates that a functional time series continuous statistical approach makes sense.



Impact so far

With clear demand from the glaciological community for improved modeling capacity, this modeling tool will change research practice and enhance understanding.

Currently, we have data on the outlines of surface lakes from satellite imagery, this is hard to use to understand properties that span all surface lakes and monitor changes through time.

This approach has other applications that go beyond glacier surface lakes. For example, there are lots of other cases of environmental data in similar formats which could benefit from this ability to create continuous representations.

What next?

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Finding a solution to plastic waste through a circular economy

Alison Stowell, Peter Carrington, Crispin Halsall, Leighanne Higgins, Maria Piacentini, Rachel Platel, Kirk Semple, Alex Skandalis, Ben Surridge. RAs: Lenka Brunclikova, Sam Cusworth, Marta Ferri

The challenge

We must address the plastic problem. The UK generates 3.5 million tonnes of plastic waste per annum, half of which is plastic packaging (House of Commons, 2022) and only a fifth gets recycled (WRAP, 2020). Plastics pollute our Earth and are a health risk if ingested by humans and animals alike. The UK government is committed to action, but we will need innovative approaches to meet the target of eliminating avoidable plastics by 2042.

A circular economy aims to ensure products are designed to be more regenerative, durable, reusable, repairable, recyclable and repurpose-able so that we use less of Earth's natural resources and create less pollution in the longer term. So developing circular economy solutions for plastics in the UK is crucial.

The big question

How can we create an inclusive circular economy solution for plastics?

The research

To move forward we must learn from failure. We are exploring plastic littering as an example of a failed circular economy to first identify gaps in the knowledge base about what went wrong and the social and environmental consequences of plastic litter.

Our team of researchers from different disciplines (natural, physical and social science) will then use this gap analysis to co-develop a research plan to develop an inclusive circular solution for plastics that embeds environmental, physical and social science from the start.

Findings so far

Impact so far

Produced a useable dataset bringing together academic research that combines current research from natural/social sciences.

Developed ideas for a novel, cross-disciplinary research proposal and networks that aim to investigate solutions to plastic packaging and the impacts and implications on planetary and social health.

What next?

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Can a bee's gut environment help it survive climate change?

Alexandre Benedetto, Philip Donkersley, Jack Martin, Rajal Patel, Alejandra Zarate-Potes

The challenge

Climate change and human activities are impacting our ecosystems and the insects that inhabit them. This includes pollinators like bees that are key to the sustainability of our food supplies. Pollinator populations are suffering from changes like facing new predators, pathogens, invasive plant species, pollutants, and temperature rises.

The big question

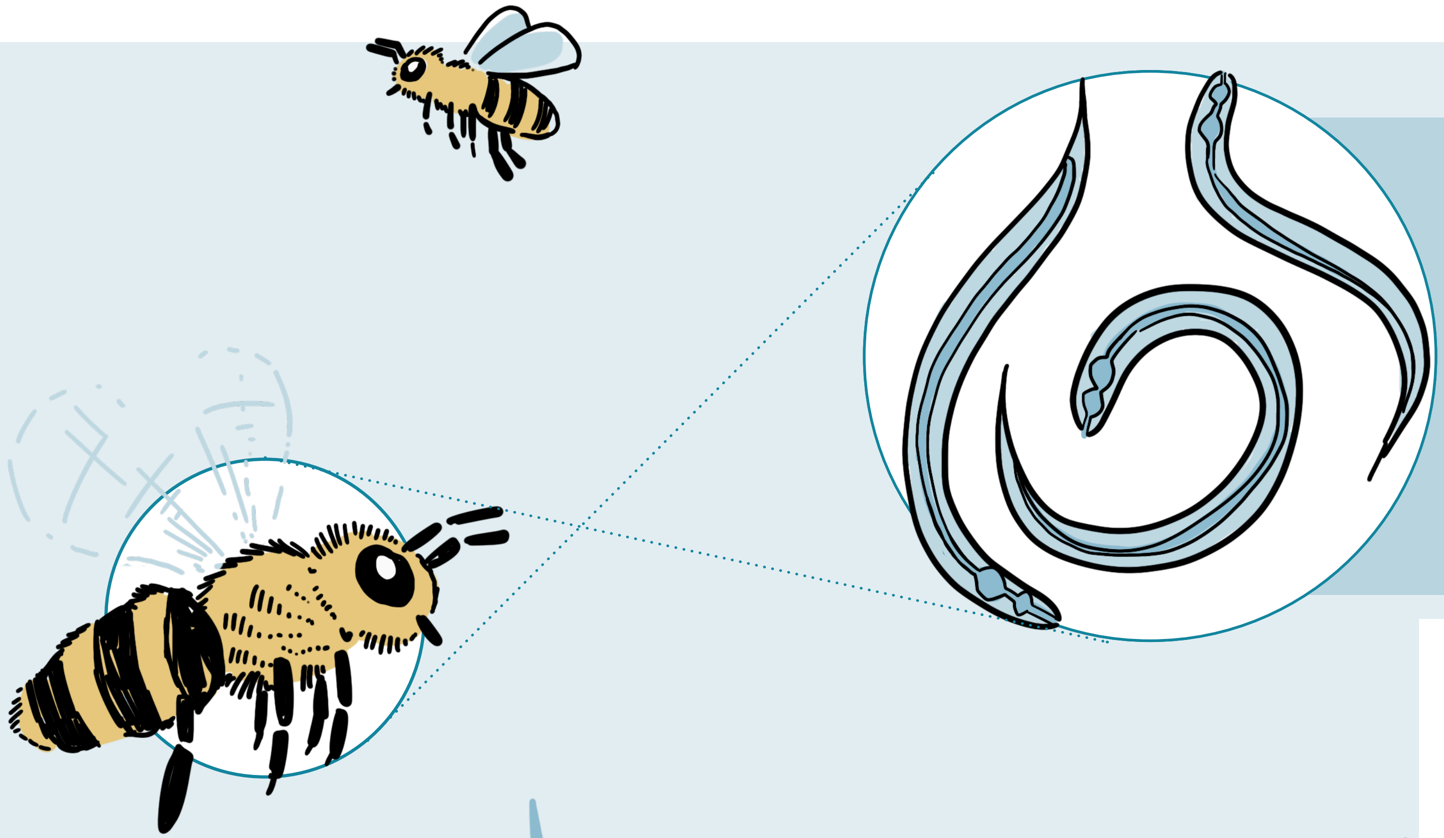
Can we improve pollinator resilience by 'boosting' their gut microbiota?

The research

It is difficult to investigate this complex problem in bees. It is easier to study it first in a model organism that has similar biology but allows us to test many different scenarios rapidly, inexpensively, and in detail.

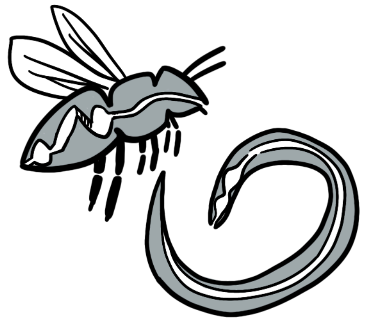
This organism is the microscopic roundworm C. elegans that eats bacteria found in compost, rotting plants and fruits.

So, we put bee gut microbes in C. elegans to test how changes in environmental parameters affect their composition and metabolism, and how all this affects their worm host.

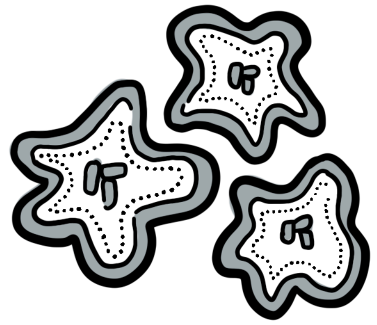


Findings so far

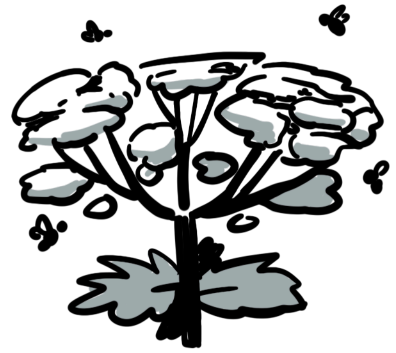
Bee gut microbes are not too dissimilar to natural microbes from the worm gut. Many microbes that live in bee guts thrive in the worm gut too.



We have characterized the metabolic requirements of three bee gut microbes so far. We also made color-coded version of them, which we have seen living in the worm gut.



Invasive plant extracts (Rhododendron, Giant Hogweed and Himalayan Balsam) impact the growth of these microbes in liquid cultures. A bees health is likely impacted by these invasive species.



Impact so far

We have proof of principle that the C. elegans nematode model can be used to study aspects of bee gut microbial ecology. This knowledge can be used by other researchers interested in similar work.

We will be working with Fera Science (https://www.fera.co.uk/) to conduct actual bee experiments after we have found promising microbial cocktails that improve worm resilience.

What next?

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Insights into volcanic ash generation from material sciences

Steve Lane, Jennie Gilbert, Mike James, Thomas Jones, Hugh Tuffen, (all from LEC at Lancaster); Michael Herzog (University of Cambridge) and Tao Liu (Queen Mary, London)

The challenge

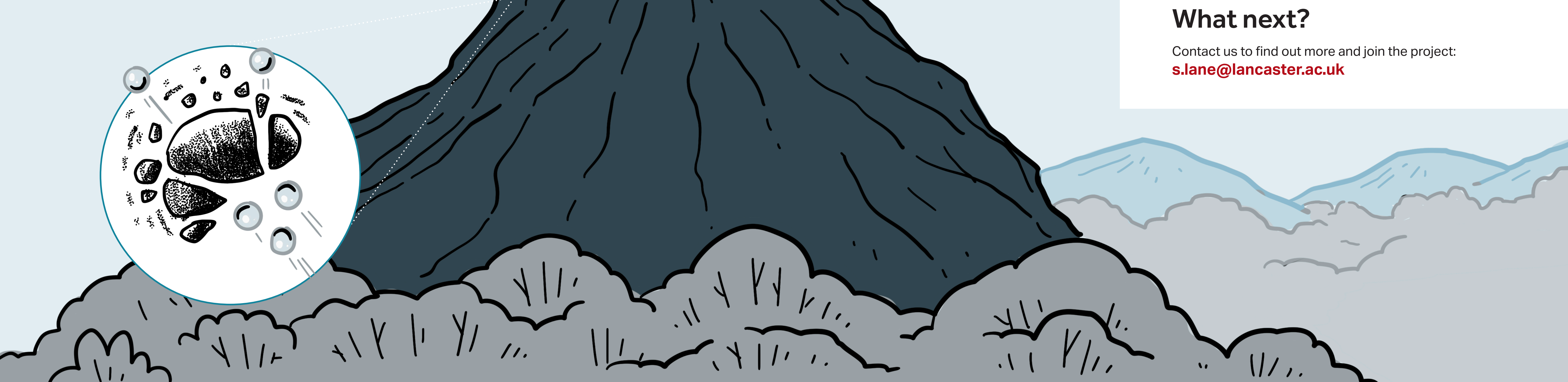
Volcanic ash particles damage, disrupt, and destroy. Ash causes respiratory problems, environmental damage, and disruption to air travel. Understanding how volcanic ash is generated will help us to address these problems.

The big question

How are volcanic ash particles generated and can we better forecast their dispersal in the environment and their impacts?

The research

To understand ash generation we blast foamy magma (pumice) apart with metal balls and closely examine the particles that are generated. This project combines diverse expertise in geology and the physics of ash production and transport, with material science and engineering perspectives on cellular solids to build a new framework for volcanic particle paths from the subsurface of the Earth to the environment.



Findings so far

Our pumice-blasting experiments highlight major gaps in current understanding of how volcanic ash is generated:

Pumice absorbs much of the collision energy but the impact generates tiny particles.

New discovery - the finest volcanic ash can actually be generated from low-energy processes.

Our new framework considers the strength of pumice and how particles collide.

Recommendation - We need to fundamentally rethink volcanic particle generation

Impact so far

Our preliminary data is informing development of a new large scale research programme

What next?

Contact us to find out more and join the project:
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Data science interrogates the energy and economic potential for floating solar photovoltaics

Alona Armstrong, Andrew Folkard, Sofia M G Rocha, Mark Shackleton,
Steve Thackeray (UKCEH)

The challenge

Our quest to decarbonise our energy system is driving us to find new ways of generating renewable energy from our environment. The successful growth of solar photovoltaics has led to their deployment not only on land, but increasingly on water bodies. Yet we have little knowledge of the effects these have on water ecosystems, how the electricity generated from them may differ from land-based installations, and the economic implications and opportunities. For example, does it make sense to combine floating solar and hydropower installations?

The big question

What is the global potential for adding floating solar panels to hydropower plant reservoirs? If it makes sense, where shall we put them?

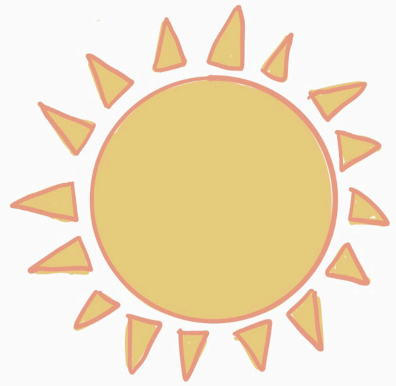
The research

In this research we are developing a picture of how floating solar could physically affect water bodies, their hydropower potential and the economic implications. We investigate existing global hydropower capacity - where is it located and how efficient the hydropower plants are. We look at how much energy is generated compared to capacity. Then we estimate the financial cost of floating solar panels at hydropower plants to boost the energy capacity. This can help us recommend the most technically and financially attractive regions for investment.

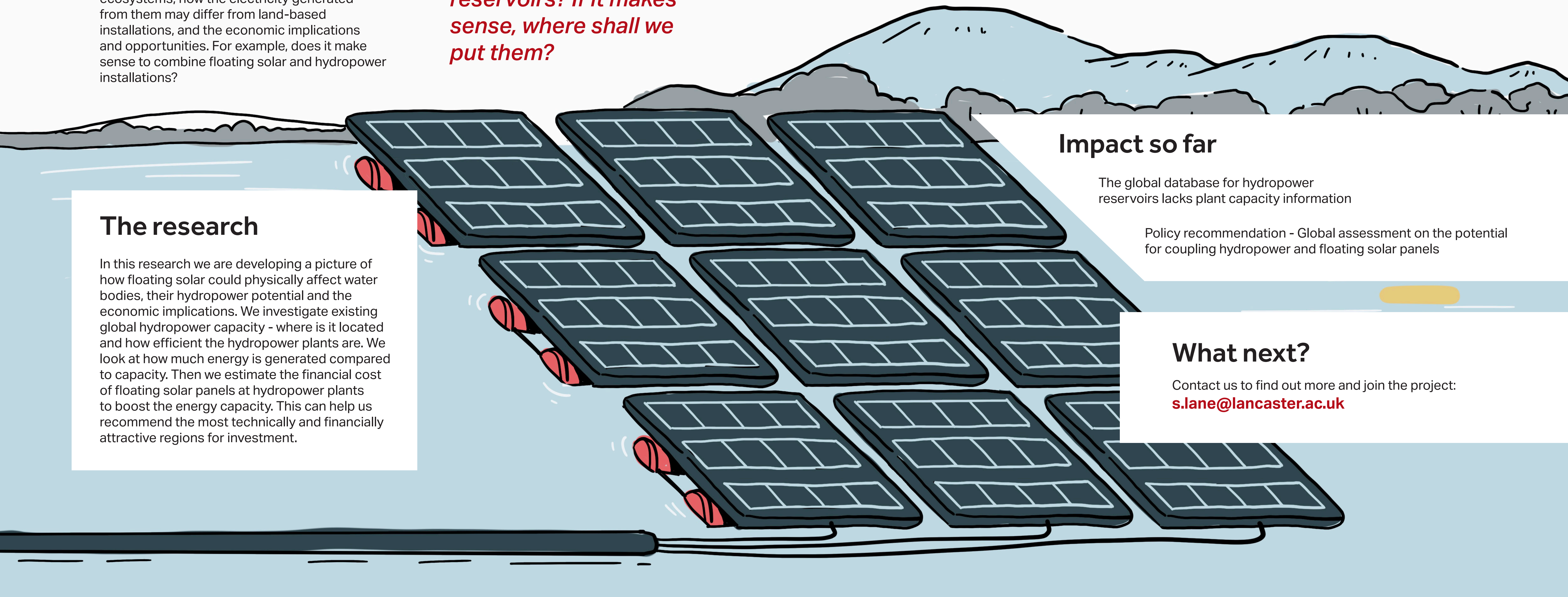
Findings so far

The global database for hydropower reservoirs lacks plant capacity information

Predicting floating solar panel costs is challenging as the technology is new



Tropical regions might be more expensive given the high water level variabilities, although they have the greatest solar radiation



Impact so far

The global database for hydropower reservoirs lacks plant capacity information

Policy recommendation - Global assessment on the potential for coupling hydropower and floating solar panels

What next?

Contact us to find out more and join the project:
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Closing Remarks

To understand our complex environment and adapt to our growing environmental challenges we need new vibrant and innovative cross-disciplinary research collaborations. By bringing our knowledge and methods together across disciplines we have a better chance of building a more sustainable, prosperous planet.

Beyond the fund, the project groups have initiated many other conversations that will continue across traditional disciplinary boundaries and hopefully evolve into longer-term projects and outcomes.

Support is needed to nurture these types of partnerships beyond the short term. We have started these seven groups on a journey to new environmental knowledge and capacity to manage our future on Earth and remain committed to finding ways to sustain their ongoing research endeavors.

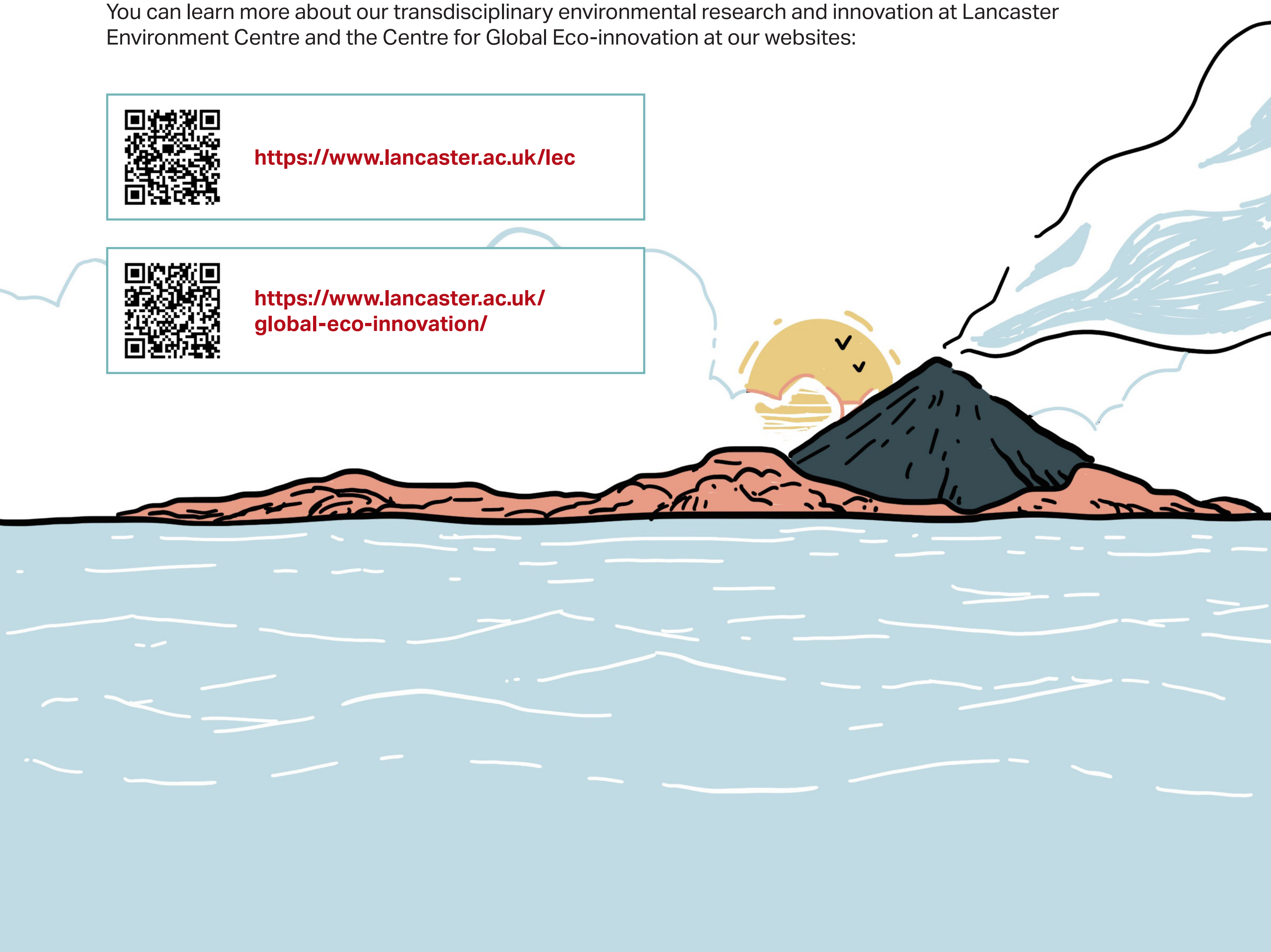
Find out more

Please feel free to get in touch with the project teams directly to learn more about their work and explore opportunities for collaboration.

You can learn more about our transdisciplinary environmental research and innovation at Lancaster Environment Centre and the Centre for Global Eco-innovation at our websites:

https://www.lancaster.ac.uk/lec

https://www.lancaster.ac.uk/global-eco-innovation/



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