



UK Research and Innovation

Guidance for developing and submitting ideas for strategic research highlight topics

NERC is inviting ideas for scientific advances that address the challenges set out in our strategy *The Business of the Environment*: benefiting from natural resources; resilience to natural hazards; and managing environmental change.

Ideas submitted by the community through this process will primarily be used to develop highlight topics, but ideas may also be used to develop investments through other funding routes.

There will be a separate call for ideas to develop other strategic investments.

What is an 'idea'?

By an 'idea' NERC means a statement of a possible course of research, presented for example as a sharply focussed question, gap, challenge or opportunity, that the proposer(s) consider would contribute to the delivery of the NERC strategy goals (benefiting from natural resources; resilience to environmental hazards; managing environmental change). An idea should not be framed as a proposal on how to deliver specific science advances, but should instead set out where science advances are needed. This invitation is to submit ideas for strategic research and NERC's agreed definition of strategic research is as follows:

NERC's main goals are to understand and predict how our planet works, to manage our environment responsibly as we pursue new ways of living, doing business, escaping poverty and growing economies, to broker strategic partnerships and to invest in world class skills to maintain the health of the UK environmental science community for the longer term. NERC strategic research should deliver new understanding that will, over time, contribute to addressing some of these major challenges of the 21st century: benefiting from natural resources, resilience to environmental hazards, and managing environmental change. Supporting and developing areas of world-leading scientific endeavour that are relevant to these goals is therefore strategic, including supporting such science whose specific benefits will become clear some time after the research is undertaken.

NERC is seeking ideas for highlight topics. Ideas for highlight topics should be sharply focused defined topic areas that can be delivered by independent projects up to the value of £4 million over a maximum of four years. Highlight topics should not require NERC to partner with other funding agencies in order to deliver the project.

An idea is not the same as a discovery science large grant outline. Large grant outlines state a problem and series of clearly defined science questions and then outline how a particular team will address these. Strategic research ideas outline an area of research that needs concerted effort to make progress, and provides evidence that such progress is possible, but does not outline how specifically the progress can be made. For example, an idea can be persuasive if it can point to broad areas of innovation in analytical, modelling or measurement technologies that offer possible new insights into a hitherto intractable problem; a large grant outline would describe specific

methodological routes to progress (including who would do the work).

There will be a separate call for ideas for strategic programme areas. These should address large scale science questions where the research is expected to be complex, logistically challenging, and/or there are significant opportunities for partnership. The programmes will require a community effort to deliver and may be up to £20 million over six years, depending on their scope.

Submitting an idea

Ideas can be developed by an individual or group within the research community. Ideas from those who use environmental science, such as business and policymakers, are also encouraged. It should be noted that there is no NERC funding available to support the development of ideas, but NERC staff are available to discuss your ideas and provide advice, especially on sections where you feel you might find it difficult to provide the level of specificity we have requested. In addition, NERC staff can:

- Identify related current investments or critical masses of expertise in particular science areas through research programmes or projects, and facilitate users to connect with relevant expertise to seek input into ideas.
- Direct users to relevant events convened by other organisations, such as learned societies, which often hold discussion meetings on topics of relevance to NERC's remit/strategy and will in some cases proactively organise the community to identify research priorities.

If you have any queries on the process or would like advice on a potential idea please contact us at idea@nerc.ukri.org in the first instance, and we will put you in touch with a NERC colleague who can help.

There is no limit on the number of ideas that each individual can submit, but each idea is evaluated on its own merits; there is no benefit in the prioritisation process of submitting multiple very similar ideas.

Example ideas

Two examples of ideas that had a useful level of specificity are included at **Annex A**. There is no perfect exemplar but these example ideas set out where scientific advances are needed to resolve issues, but importantly are not framed as proposals on how to deliver the scientific advances.

- What is the 4PM? New understanding of soil organic carbon persistence to meet C offset targets
- New Insights into the Space Weather Impact on the UK National Grid

On-Line Form

Ideas should be submitted on the on-line form, and include the following information:

- **Title**
- **Statement of the idea:** a short summary of the idea, around 200 words, suitable to be published on the NERC website
- **Research question(s):** a description of the scientific advance needed, its timeliness and

novelty. The advances should be well-defined and specific and include relevant citations. They should be appropriate in scale for a highlight topic.

- **Challenges:** a description of the impact the research will have, including relevant citations. Include specifically how the idea and expected outcomes of research will contribute to the understanding of at least one of NERC's challenges.
- **Capacity:** whether the UK community has the capacity and infrastructure needed to do the research, including, if applicable, how the research builds on and complements existing activities and utilises NERC infrastructure. Required new capital investments and evidence for training needs should be specified in this section.
- **How the idea originated and has been developed:** including a note of the organisation(s) involved, and how the idea was generated, e.g. through workshops. This section should not include any individually identifiable information.
- **Identify why this idea is a highlight topic:** identifying why a highlight topic (sharply-focused defined topic areas) investment is most appropriate for the idea.

The ideas should be submitted via the [online form](#). The form also includes identification questions and classification questions for analysis of the ideas by NERC. Ideas can be submitted to NERC at any time, although there will be regular cut-off dates for ideas to be considered by NERC in a particular round. The [cut-off dates](#) will be published on the NERC website.

ODA research and the ideas process

Calls under the Global Challenges Research Fund (GCRF) and Newton Funds will continue to be the primary avenue for supporting Official Development Assistance (ODA) - eligible research. However, for the next cut-off and until advised otherwise, ODA eligible research ideas can be submitted to the highlight topic ideas process.

National capability and the ideas process

NERC's national capability (NC) funding supports science that is vital for UK environmental science in the long term, but whose scale and complexity means it cannot be delivered in an openly competitive way. For example, capability may only exist in one place such as in NERC's research centres or large research infrastructure (e.g. ships, aircraft and polar bases). Programmes funded through NC can provide the foundation for other NERC-funded activities and NERC welcomes the submission of ideas which build upon and maximise the value of science and infrastructure funded through NC.

What happens to ideas?

Once an idea is submitted to NERC, the proposer relinquishes ownership of that idea and it becomes owned by NERC. There is no further input from the community. The ideas will be reviewed by Science Committee and a decision made on the next potential highlight topics areas. The decision makers will not know the identity of those submitting ideas, but will have information on whether the idea was developed by an individual or a group. Prioritisation will be based on the following criteria:

Criteria	How assessed
<ul style="list-style-type: none">• Potential for scientific excellence• Timeliness and urgency of research question• Extent to which topic is already being or has recently been funded	Research question section
<ul style="list-style-type: none">• Relevance to NERC societal challenges• Potential for economic and/or societal impact	Strategic challenges section
<ul style="list-style-type: none">• Readiness of UK research community and infrastructure	Capacity section

Process for highlight topics

We intend that highlight topics will be developed from single ideas or very few closely-related ideas; for example, two ideas may be matched up where a research user has strongly outlined a problem, which is related to an idea from a research provider specifying the science advances and UK capacity. The ideas will be reviewed and a decision made on those highlight topics to be included in the next call.

It is anticipated that each HT announcement of opportunity will be released approximately six to seven months after the HT idea cut-off.

Feedback and longevity of ideas

NERC will announce regular cut-off dates and will prioritise highlight topics from each round. After each round NERC will provide feedback to the community; we anticipate this feedback will be high level.

For ideas submitted as potential highlight topics the feedback will inform the submitter whether (a) their idea contributed to a highlight topic (b) whether it was felt to have potential but needed further development, or (c) whether it was not considered to be appropriate for strategic research investment at this time. Individual feedback will be given on the ideas in category (b) on how the ideas could be improved for future cut-offs.

Ideas have a lifetime of a single round to ensure they remain timely and resubmission is required if you would like your idea to be considered again. NERC encourages submitters to use their feedback and the ideas guidance to decide whether to resubmit ideas for future rounds.

ANNEX A: Example ideas

This annex contains two examples of ideas that had a useful level of specificity.

There is no perfect exemplar but these ideas set out where scientific advances are needed to resolve issues, but importantly are not framed as proposals on how to deliver the scientific advances:

- What is the 4PM? New understanding of soil organic carbon persistence to meet C offset targets
- New Insights into the Space Weather Impact on the UK National Grid

Example 1: What is the 4PM? New understanding of soil organic carbon persistence to meet C offset targets

Title: What is the 4PM? New understanding of soil organic carbon persistence to meet C offset targets

Statement of the idea: Recent initiatives call for a global effort to increase soil organic carbon (SOC) stocks for climate change mitigation and food security. To halt atmospheric CO₂ emissions, the “4 pour mille” initiative advocates land management options to increase SOC by 0.4% per year. However, evidence for the sequestration potential of recommended agroecological practices is scarce due to limited spatiotemporal data and uncertainties as to the long-term persistence of short-term SOC gains. Current scientific understanding cannot predict this since we do not understand the mechanisms by which C inputs are stabilised in the soil matrix. This Highlight Topic addresses the **unresolved paradox: all SOC is essentially decomposable, so why does some of it persist?** An interdisciplinary research effort is urgently required to validate options to meet carbon offset targets, and to understand the mechanisms sustaining one of the largest stores of exchangeable carbon on Earth. New research will address both the biochemical nature and origin of SOC, as well as stabilisation mechanisms through biological, chemical and physical processes interacting within land management systems. The aim is now achievable with the recent re-writing of mechanistic theories explaining SOC formation, and technological innovations for testing at appropriate scales.

Research Question(s): Soils offer significant potential to offset greenhouse gas (GHG) emissions, and evidence of robust approaches to manage soils for carbon storage could fill current policy gaps in delivering the 4th carbon budget of the Climate Change Act. More widely, the 2015 Paris Agreement on tackling climate change targeted net zero global GHG emissions in the second half of this century to limit global warming to below 2°C. All options to reduce GHG emissions must now be exploited in the shortest possible timescale to prevent reaching this critical tipping point for the global climate system. In response, the recently publicised 4 per 1000 initiative set global targets to increase SOC by 0.4% per year to neutralise current emissions (4p1000.org). However, a lack of spatiotemporal data limits the evidence base for implementing land management recommendations to meet offset targets. For example, advocated agroecological approaches for soil carbon sequestration such as conservation tillage may not be as effective as initially claimed (Powelson et al, 2014) due to uncertainties regarding the long-term stabilisation of short-term accrued C. **Therefore, a new mechanistic understanding of SOC persistence and assessment of novel derived indicators must be developed to prescribe robust land management practices that increase C storage over societally relevant timescales.**

Limitations in current understanding of SOC persistence are due to previous technological difficulties in studying soil processes. Thus, current soil models remain largely based on the assumption that persistent SOC consists of recalcitrant “humic” macromolecules formed by undefined transformations of organic inputs, a legacy of a popular lab extraction procedure that has now been replaced (Kleber & Johnson, 2010). Recent research suggests that the dominant forms of stabilised SOC are in fact chemically labile (as undecomposed plant matter, microbial cellular products or metabolites) but unavailable to decomposition agents due to: i) chemical and physical protection through organomineral sorption and/or occlusion within aggregates; and ii) biological mechanisms governing the nature and rates of transformation processes. New technologies including “omics”, isotopes and physical imaging now facilitate a detailed assessment of these processes, facilitating the testing of hypotheses of SOC stabilisation by providing new quantitative evidence

for persistence mechanisms. Specifically, new research needs to determine the biochemical nature and production pathways of SOC pools with different stabilities, and establish how management affects the biological and physico-chemical regulation of process rates at appropriate scales. **Strategic outcomes will be the advancement of knowledge on soil C sequestration potential, with an efficacy assessment of how changing land management affects short-term SOC persistence indicators (microbial degradation products or stabilising factors).** Longer term this will also permit the development of advanced management strategies founded in process understanding.

Kleber & Johnson, *Advances in Agronomy*, ELSEVIER, 106:77-142, (2010); Powlson et al, *Nature Climate Change* 4, 678-683 (2014)

The research will answer the following questions:

1. *What are the biological, biochemical, and environmental processes controlling the transformation of organic inputs into persistent SOC entities?*
2. *How do these persistent entities emerge via biological, chemical and physical processes at soil pore to aggregate scales over time?*
3. *Can land management control the quantities of stabilised SOC stored in soil via these processes?*
4. *Can SOC persistence be further enhanced through knowledge of process mechanisms, i.e beyond 4PM?*

Challenges: This topic addresses two of NERC's societal challenges, including "Benefit of natural resources" and "Managing environmental change". Soil is one of the most important natural resources sustaining life, wellbeing and economic activity; yet it is also under threat from overexploitation, urbanisation and climate change. New research that reveals the fundamental processes governing SOC dynamics is urgently needed to develop integrated approaches to managing soils sustainably for the future. Building and maintaining SOC is essential not only for C sequestration for GHG mitigation, but also for healthy soil function.

Capacity: UK science is now in a unique position to address this globally relevant challenge, having long-standing track record in soil carbon research through: soil-C assessment and characterisation methodologies; field monitoring of stocks through globally unique long term experiments (Rothamsted LTE) and monitoring programmes (National Soil Inventory, Countryside Survey); and modelling with respect to land use and climate change (Roth-C). New technologies will be at the forefront of these studies including omics (metagenomics, proteomics and metabolomics), advanced analytical chemistry (including spectrophotometry, advanced mass spectrometry), radiocarbon dating and stable ¹³C isotopes, physical imaging (Synchrotron X-ray CT) and modelling. Many of these technologies are currently supported through several National Capability facilities including the NERC Biomolecular Analyses facilities, Mass Spectrometry and Radiocarbon facilities and STFC Diamond. Rarely in soil science are these technologies used in concert, and the challenge of understanding soil C storage will explicitly require and invoke cross disciplinary partnerships. Research will be underpinned by new science and networks arising from several large programs, which investigated relationships between land use and wider soil ecosystem services/nutrient dynamics (NERC SSP, BESS, Macronutrients) though not the specific underpinning mechanisms of soil C storage. However to advance soil C research will require wider collaboration across other disciplines including microbiologists, molecular scientists, ecologists, cellular physiologists, biogeochemists, physicists and process modelers.

How the idea originated and has been developed: The idea originated through a workshop coordinated by the Soil Security Programme at Reading in 2017. The workshop was attended by Programme participants and a range of other relevant academics from multiple disciplines including soil, molecular, microbial and marine sciences from both Universities and NERC/BBSRC research institutes. Also in attendance were other key stakeholder representatives from DEFRA and the Environment Agency. Further relevant participants in developing the idea were also identified at the meeting and invited to contribute to the proposal.

Identify why this idea is a HT: This topic is timely due to recent policy initiatives such as 4 per 1000 and related evidence gaps which cannot currently be addressed using long term field data. We note a willingness to adopt alternative management by farming groups (*#rootsnotiron*) but there is an immediate need to provide temporally robust indicators of efficacy. Scientifically this a globally emerging topic, due to the recognised importance of soil C in sustaining societies coupled with new theories and technologies for assessment. To fully develop a process based understanding of SOC persistence requires a multidisciplinary "systems" approach encompassing lab studies of agronomically relevant managed soils. The focus on biotic and physical mechanisms offers scope for a range of projects addressing components of each mechanism. The results will have direct impact on both agronomic and climate areas with wider societal and economic

relevance, and the technological advancements arising from research partnerships will strengthen a range of scientific disciplines (terrestrial and aquatic sciences).

Example 2: New Insights into the Space Weather Impact on the UK National Grid

Text of the idea that was submitted to NERC

Title: New Insights into the Space Weather Impact on the UK National Grid

Statement of the idea:

Space weather links solid Earth, atmospheric, ionospheric and magnetospheric processes providing cross-disciplinary research opportunities on a natural hazard now established on the National Risk Register. In this Highlight Topic we focus on the rapid, high amplitude geomagnetic field variations, caused by space weather, that drive damaging Geomagnetically Induced Currents (GIC) through conducting networks such as power grids, pipelines and railways. Though existing UK GIC models are recognized for their geophysical detail, new insights are needed on the science underpinning these models. For example, what is the appropriate spatial and temporal characterisation of ionosphere electrical currents in respect of GIC, what can we learn from the limited verification of modelled UK geo-electromagnetic fields, and what is the best 3D model of subsurface electrical conductivity? Furthermore, industry needs GIC forecasts to prepare for impacts on electricity transmission. However GIC forecasting is a 'hard' geophysics problem, because of the non-linearities of the coupled Earth system, driven as it is by the solar wind. We therefore propose in this Topic to enhance our geophysical understanding of how the UK near-surface and subsurface responds to space weather. This will require more sophisticated modelling and monitoring and will ultimately lead to tools for assessing space weather impact on grounded infrastructures like the National Grid, together with industry and other partners.

Research Question(s): Advances needed, their novelty and timeliness

NERC GIC models have gradually developed in association with the UK power industry over more than 10 years. But it is time for a step change in modelling capability and accuracy, as the current generation of models have significant scientific limitations, revealed by recent validation against measurements, and limits in operational settings, because industry's needs have evolved. By concentrating on the following research questions NERC can reach a new level of scientific knowledge in this field and create a new generation of world-leading research models with operational value, in a time frame better suited to industry and other stakeholder needs.

RQ1 - Ionospheric and magnetospheric processes

- How do ionospheric electrical currents respond to space weather forcing? How does the morphology and dynamics of current systems change under higher levels of forcing? What are the extremes in ionospheric currents at mid and high latitudes?
- What is the relative significance of, and interaction between, the ionospheric-magnetospheric current systems and their dynamics in terms of ground magnetic variations, under varying space weather forcing? What spatial and temporal scales in these magnetic variations are most significant in terms of GIC?
- What are the limits to forecasting in the ionospheric-magnetospheric system and what are the implications, e.g. in terms of quantifiable uncertainties, in forecasts of GIC in power grids?
- Are there meso- (i.e. UK continental shelf) scale geomagnetic processes that are not resolved by the current UK magnetometer network? Is any such structure related to, or predictable from larger scale or mean fields? How does any meso-scale structure influence generation of GIC?

RQ2 - Solid Earth processes and structures

- How does the surface electric (telluric) field behave at major shallow and 3D conductivity contrasts during magnetic storms, particularly at the coast where electricity generation is concentrated?
- What is the relative importance of deep (~hundreds of km) and shallow (~few to tens of km) conductivity and of magnetic variations, on surface electric fields driven by space weather?
- How do decadal, or longer, changes in the Earth's magnetic field generated in the core influence the structure and dynamics of ionospheric-magnetospheric currents? What are the potential impacts in terms of GIC on grounded infrastructure?

Challenges:

Resilience to Environmental Hazards

The challenge in this Highlight Topic is to better understand our changing resilience to the natural hazard of space weather within a critical national infrastructure, the National Grid. Addressing the specific Challenges 1 & 2 below will therefore have impact through the development of models and tools that can be used to better assess the exposure of the Grid to this hazard.

Challenge 1 - Ionospheric and magnetospheric processes

Coupled ionospheric-magnetospheric current systems generate ground-level magnetic field changes that create GIC through an induced electric field in the Earth. The dynamics of these currents have a complex dependence on energy and plasma extracted from the solar wind. Existing models of these currents are largely derived from satellite measurements in orbits beyond a few Earth radii. However the electrical currents in the magnetosphere and ionosphere that drive significant GIC in the UK are much closer to the Earth's surface and are poorly represented in existing GIC models. We need progress on the novel research questions (RQ1 above) to improve models of ionospheric-magnetospheric current systems close to the Earth, ultimately leading to a predictive GIC capability driven by solar wind measurements.

Challenge 2 - Solid Earth processes and structure

The surface electric field induced in the Earth that drives GIC in the grid is sensitive to Earth conductivity and geological structures. However, present day conductivity models have limited parameterisation of 3D varying structure and often lack shelf-sea, deep-sea and sediment conductivities, particularly important for the UK. Electric fields are also not widely monitored, so models lack country-wide validation. Nor do we understand how long term changes in the Earth's core magnetic field affects the ionosphere-magnetosphere 'climate' and the significance of this for GIC. To improve our models of surface electric fields and of solid Earth control on the ionosphere-magnetosphere environment, we need to address the key questions identified at RQ2 above.

Capacity:

This Highlight Topic should encourage cross-disciplinary research into coupled geo-electromagnetic processes from the deep subsurface to near-Earth space, as it builds on existing academic and industry partnerships. For example, BGS operates the NERC magnetic observatory network and has more than 15 years' experience in modelling GIC in the UK grid in association with National Grid, Scottish Power, EDF and ESA. Expertise in ionospheric and magnetospheric activity, driven by the solar wind, exists at BAS, RAL and the University of Lancaster. Lancaster runs the SAMNET magnetometer array and operates a popular outreach project, 'Aurora Watch'. Edinburgh, Liverpool and Leeds Universities are strong sources of expertise in solid Earth Geomagnetism. Met Office has been the UK lead space weather forecaster since 2014.

How the idea originated and has been developed:

This idea originated through workshops (2012-) on space weather and GIC, involving Leeds, Edinburgh, and Lancaster universities and BGS, BAS, Met Office and RAL Space. The idea has further benefited through recent international partnerships and workshops, with NOAA & NASA, supported by the Foreign Office and Cabinet Office Civil Contingencies Secretariat, and workshops supported by the EU Joint Research Centre, European Space Agency and the insurance industry ('Geneva Association'). This Topic should facilitate a partnership between NERC, Met Office, National Grid, electricity utilities and Government, with economic and societal impact and recognition at international level.

Identify why this idea is a HT:

This Topic is highly focused on better monitoring, specification and forecasting of a particular aspect of space weather, GIC, and its impact on the National Grid. However there is a wider scientific gain: better understanding of geophysical processes in the near-surface and subsurface geo-electromagnetic environment across the UK and the response of these processes to forcing by solar activity. Additionally, any potential capital investment (magnetometers, telluric probes) is relatively inexpensive and scientific expertise in the UK is concentrated in a few institutions.