PROJECT TITLE: Sink or Source (SOS) - Soil Carbon Dynamics in a High-CO_2 World

DTP Research Theme(s): Dynamic Earth, Living World, Changing Planet

Lead Institution: University of Bristol
Lead Supervisor: Dr Timothy Knowles, School of Chemistry, University of Bristol
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Project keywords: carbon cycle, climate, soil, radiocarbon, isotope

Growth chamber with gas flux monitoring

The Bristol MICADAS accelerator mass spectrometer

Project Background: Soils store around 75% of terrestrial carbon, with soil organic carbon (SOC) holding more carbon than the atmosphere and plant biomass combined. The potential for soils to become net carbon sources to the atmosphere under a changing climate represents a major tipping-point risk. It is crucial to understand how increasing atmospheric CO_2 levels affect carbon uptake, storage, and release in soil organic matter at the molecular level in order to predict responses to future climate scenarios. Cutting-edge incubation and free air CO_2 enrichment (FACE) experiments, along with radiocarbon and stable isotope techniques, provide an ideal opportunity to study these processes; we can manipulate CO_2 levels, and apply compound-specific stable isotope (^{13}C) and radiocarbon (^{14}C) tracer approaches to follow atmospheric CO_2 carbon through the entire soil carbon cycle.

Project Aims and Methods: This exciting PhD opportunity will use the latest radiocarbon accelerator, and isotope ratio mass spectrometric instrumentation and advanced complementary techniques to investigate the effect of elevated CO_2 on the ability of forest and grassland soils to act as a carbon sink. The project aims to quantify the pathways, rates, and fluxes of carbon from atmospheric CO_2 into various soil carbon forms and their subsequent stabilization. Soil/plant mesocosm incubation experiments will be conducted, with samples collected over time to determine the fate of atmospheric CO_2. Radiocarbon and stable isotope analyses at the bulk- and compound-specific level targeting root exudate compounds and phospholipids will help determine the mechanisms by which carbon sequestration/loss occurs. Moreover, the effect of elevated CO_2 on the nature of stored C, at the molecular level and how this affects carbon sequestration, shall be determined. The candidate will also measure ^{14}C levels in soil-respired CO_2 to assess the balance between these soils as sources or sinks under elevated CO_2 conditions. This PhD project will involve aspects of experimental design, building incubation apparatus and modifying analytical procedures to enable these innovative analyses. This initial work will feed into larger scale experiments with soils from FACE sites and aligns closely with an ongoing NERC funded research project (Pushing the Frontiers; NE/X014851/1). Within overarching goals, the student will be encouraged to direct their research with supervisors providing all necessary support.

Candidate requirements: A profound interest in biogeochemistry, climate change and a commitment to positive science-led change is fundamental to this project. A background in analytical chemistry is essential and a background in Earth/soil sciences highly desirable. Also key are good laboratory and data analytical skills coupled with a willingness to learn new techniques and develop existing ones. An aptitude for statistical analysis and a knowledge of R would be desirable. We welcome and encourage student applications from under-represented groups and we strongly value and support a diverse research environment.

Project partners: The Organic Geochemistry Unit at the University of Bristol has a long history of being at the forefront of developing and applying compound-specific stable isotope techniques to biogeochemical systems. In parallel, the Bristol Radiocarbon Accelerator Mass Spectrometry (BRAMS) Facility is equipped with the latest generation of radiocarbon accelerator and supports cutting-edge compound-specific radiocarbon analyses. The University of Exeter is a UK centre of expertise for carbon cycle and climate science and has developed novel laboratory and field techniques for studying soil C dynamics, including novel approaches for tracing ^{13}C into different soil fractions, as well as CO_2 and CH_4 emissions.

Training: Training in biogeochemistry, radiocarbon science and analytical chemistry will be provided in both BRAMS and the OGU at the University of Bristol. Full one-to-one training will be provided for all instruments and techniques relevant to the project, including GC-C-IRMS, EA-IRMS, GC-HRMS, GC-PFC and AMS. The student will have the opportunity to attend a wide variety of internal UoB courses (*via* the Bristol Doctoral College) and lectures, including training in statistical analysis in addition to personal development courses throughout the project. External training courses will be encouraged where appropriate. Fieldwork and sampling trips will also be an integral part of this project. Extensive training around soil incubation and labelling using experimental mesocosms as well as additional techniques for soil characterisation will be provided at the University of Exeter. Communication skills are fundamental to success as a researcher, and opportunities to present your research (e.g. papers, international conferences, public engagement) will be encouraged.

Background reading and references: Stewart CE et al. (2007) Biogeochemistry 86, 19, Carney, K. M. et al. (2007) PNAS, 104(12), 4990–4995, Dietzen, C. A. et al. (2019). Global Change Biology, 25(9), 2970–2977

Useful links

http://www.bristol.ac.uk/chemistry/courses/postgraduate/

Bristol NERC GW4+ DTP Prospectus:
http://www.bristol.ac.uk/study/postgraduate/2024/sci/phd-great-western-four-doctoral-training-partnership-nerc/

How to apply to the University of Bristol:
http://www.bristol.ac.uk/study/postgraduate/apply/
Please note: If you wish to apply for more than one project please contact the Bristol NERC GW4+ DTP Administrator to find out the process for doing this.

The application deadline is Tuesday 9 January 2024 at 2359 GMT. Interviews will take place from 26 February to 8 March 2024.

For more information about the NERC GW4+ Doctoral Training Partnership please visit
https://www.nercgw4plus.ac.uk

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