EARTHSCIENCES

River methane leaks: novel methods to quantify and fingerprint river methane emissions

Primary supervisor:	Prof. Bob Hilton
Co supervisor(s):	Prof. Josh Dean (University of Bristol) Dr. Ross Morrison (CEH) Prof. Helen Johnson
Research theme(s):	• Earth Resources • Oceanography, Climate and Palaeoenvironment
Eligible courses for this project:	• DPhil in Earth Sciences • Environmental Research (NERC DTP)

Overview

Methane (CH_4) is a potent greenhouse gas whose concentration is increasing in the atmosphere. Aquatic systems are known to be important sources of CH_4, with flowing water through the subsurface allowing a route of CH_4 out of deep soils and peats, into streams and rivers. This leak of CH4 from terrestrial systems add up, with streams and rivers emitting 27.9 $TgCH_4\ yr^{-1}$ (Rocher-Ros et al., 2023). The CH_4 carried by rivers and released to the atmosphere includes CH_4 from perturbed sources in warming soils, in addition to enhanced CH_4 supply from anthropogenic activities (agriculture and waste water).

However, at present we still lack critical information on the source and fluxes of CH_4 in rivers. Part of this stems from a lack of direct measurements, and is hampered by the difficult of collecting measurements and samples over weeks to months. A new set of technological developments, however, are allowing us to use isotopes to track CH_4 source and pathway in rivers (Garnett and Dean, 2024), alongside the other major river greenhouse gas carbon dioxide (Dasari et al., 2024). In addition, passive flux measurement techniques such as Eddy Covariance, offer much promise. CH_4 measurements can be collected across storm events, diurnally, and over month-long periods, while we quantify hydrological variability to constrain how river flow contributes to CH_4 release.

This project will further develop and apply novel approaches to quantify CH_4 fluxes and sources in rivers. The topic of focus can include urban and anthropogenic CH_4 inputs, and/or perturbed natural landscapes, where the impacts of climate change (temperature and hydrology) are altering greenhouse gas supply and release from river surfaces. The greenhouse gas measurements will be combined with hydrological measurements of river flow, to help establish the combined physical and biogeochemical drivers of change.

Figure showing an Eddy Covariance site newly established on the River Thames, UK, and right a part of the Mackenzie River Delta, where ongoing change is influencing CH_4 production and fluxes.

Methodology

The project will combine novel measurements of greenhouse gas fluxes (using Eddy Covariance); hydrometric measurements of river flow (using ADCP data); greenhouse gas geochemistry (concentrations, stable isotopes, radiocarbon). UK based field work will be completed, and potentially a second field site where other environmental forcings are at play. Depending on the student's interests, numerical approaches can be applied to model how river flow impacts gas release.

Timeline

Year 1: Training and establishment of Eddy Covariance sites; Training in hydrometric data collection; training in CH_4 sampling and isotope methods

Years 2-4: Collection of CH_4 samples for isotopic analysis; NERC Isotope Facility training and grant application; additional field deployments and experiments; Data integration, thesis completion, papers for international journals/conference presentation.

Training & Skills

Greenhouse gas fluxes; data processing; hydrological measurements; isotope geochemistry;

References & Further Reading

S. Dasari, M. H. Garnett, R. G. Hilton, Leakage of old carbon dioxide from a major river system in the Canadian Arctic, *PNAS Nexus* 3 (2024), https://doi.org/10.1093/pnasnexus/pgae134

M. H. Garnett, J. F. Dean. A time-integrated sampler for radiocarbon analysis of aquatic methane, Radiocarbon 66 (2024), 421–35. https://doi.org/10.1017/RDC.2024.31

G. Rocher-Ros, E.H. Stanley, L.C. Loken, et al. Global methane emissions from rivers and streams. Nature 621 (2023), 530–535 https://doi.org/10.1038/s41586-023-06344-6

Further Information

Contact: Bob Hilton (robert.hilton@earth.ox.ac.uk)