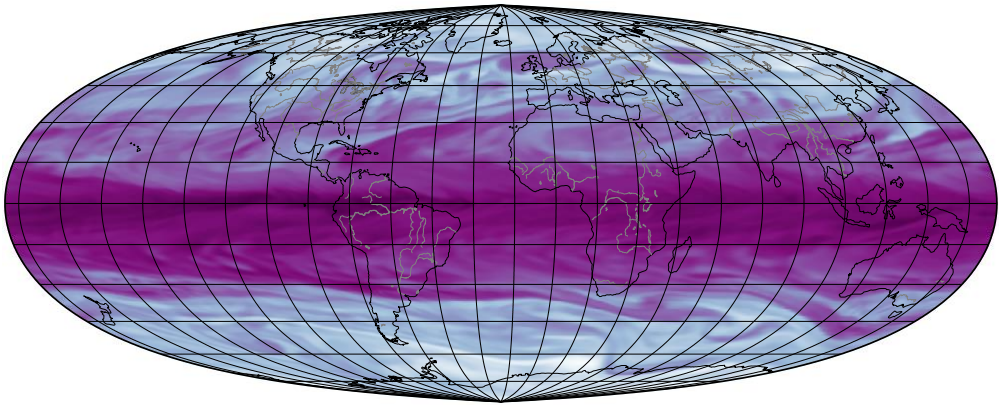
PROJECT TITLE: Evaluating greenhouse gas emissions using satellite data and machine learning

DTP Research Theme(s): Changing Planet
Lead Institution: University of Bristol
Lead Supervisor: Dr. Rachel Tunnicliffe, University of Bristol, School of Chemistry
Co-Supervisor: Prof. Matt Rigby, University of Bristol, School of Chemistry
Co-Supervisor: Prof. Anita Ganesan, University of Bristol, School of Geographical Sciences
Co-Supervisor: Dr. Alice Ramsden, Met Office, Hadley Centre
Project Enquiries: rachel.tunnicliffe@bristol.ac.uk
Project keywords: greenhouse gas, climate change, carbon dioxide, methane



Simulation of methane concentration in the upper atmosphere using the MOZART model (Matt Rigby)

Project Background

Through the work of the Atmospheric Chemistry Research Group (ACRG) and the Met Office, the UK is world-leading in the estimation of greenhouse gas (GHG) emissions using atmospheric data. The next frontier in this field is the use of satellite data to learn new insights about the global carbon cycle and atmospheric methane budget. The recent launch of space-based instruments such as TROPOMI on ESA's Sentinel 5-Precursor, or NASA's Orbiting Carbon Observatory (OCO-2) are providing carbon dioxide and methane data at a resolution and level of spatial coverage orders of magnitude higher than previous systems. However, our current tools, which have been developed primarily for national *in situ* monitoring infrastructure such as that of the Detection and Attribution of Regional GHG emissions in the UK project (DARE-UK), are ill suited to the estimation of GHG fluxes from such enormous datasets. In this studentship, you will develop novel approaches for the estimation of GHG flux at urban through global scales to help us tackle some of the most pressing questions regarding the changing concentration of atmospheric GHGs.

Project Aims and Methods

Our team has shown that GHG emissions can be inferred at national scales from the previous generation of satellite observations, based on simulations of atmospheric gas transport using the Met Office NAME model and Bayesian methods (e.g. Tunnicliffe, et al., 2021). However, the extension of current approaches to the new generation of satellite data are challenging due to the size of datasets involved. Here, we will build on our recent machine learning pilot study (Fillola et al., 2023) to explore: a) whether GHG atmospheric transport can be approximated using machine learning approaches; b) how to infer GHG fluxes from large atmospheric concentration datasets and approximate model output. These methods can be used to tackle a range of pressing challenges, such as: a) what is driving the current rapid growth in atmospheric methane? b) how is the terrestrial carbon sink changing with time? c) are national GHG emissions reports reliable?

The ACRG has a wide range of ongoing GHG science projects using atmospheric data that span urban to global scales. The student will have flexibility to align their research with any of these projects, if desired.

Candidate requirements

You should have a degree in physical sciences, mathematics or computer science and a strong desire to apply cutting edge computational and mathematical principles to environmental science. Experience in chemistry or machine learning is not required, but a good foundation in mathematics is essential. We welcome and encourage student applications from under-represented groups. We value a diverse research environment.

Project partners

This project has been jointly developed with the Met Office Hadley Centre. They will provide training on the use of the NAME model and demonstrate how GHG observations and models are used in the UK's National Inventory Report (making the UK one of only three countries to carry out such measurement-based emissions evaluation). The student will have the opportunity to work with Met Office scientists on a day-to-day basis.

Training

You will be trained in atmospheric GHG measurements and modelling and Bayesian methods. Our team of post-docs and postgraduate students will train you in computational methods and you will co-develop novel machine learning approaches with them. There will be the opportunity to work with our international collaborators, for example at MIT, with whom exchange visits can be arranged, if desired. You will have the opportunity to participate in measurement site visits. You will be trained in cloud computing techniques that have been developed through the ACRG-led OpenGHG project. You will have the opportunity to participate in meetings with GHG scientists and policy makers at national and international conferences and meetings of projects such as DARE-UK or the UK DECC network.

Background reading and references

Fillola et al., A machine learning emulator for Lagrangian particle dispersion model footprints: a case study using NAME, Geosci. Model Dev., 16, 1997–2009, https://doi.org/10.5194/gmd-16-1997-2023, 2023.

Ganesan et al., Atmospheric observations show accurate reporting and little growth in India's methane emissions, Nature Communications, 8, 1, https://doi.org/10.1038/s41467-017-00994-7, 2017.

Tunnicliffe, et al., Quantifying sources of Brazil's CH4 emissions between 2010 and 2018 from satellite data, Atmospheric Chemistry and Physics, 20, 13041–13067, https://doi.org/10.5194/acp-20-13041-2020, 2020.

Useful links

https://www.bristol.ac.uk/chemistry/postgraduate/
https://www.bristol.ac.uk/chemistry/research/acrg/
https://openghg.org

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

General Enquiries: Bristol NERC GW4+ DTP Administrator
Email: bristol-nercgw4plusdtp-admin@bristol.ac.uk