Atmospheric composition change through an isotopic lens

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Background
Atmospheric abundances of the major gases that control the Earth’s radiative budget (carbon dioxide, methane and nitrous oxide) have risen to levels not seen in Earth’s recent history. Improved understanding of atmospheric composition will improve our knowledge of the sources and sinks of these gases. While the atmospheric mole fractions of methane (CH4) have been studied extensively, the changing strength of emission sources and its sink remain uncertain. The isotopic composition of CH4 encodes extra information, and this project will explore the power of new measurements to augment the analysis of simple mixing ratios. This will involve atmospheric modelling, flask sampling campaigns and laboratory measurements, collaborating with partners at the National Physical Laboratory (NPL) and the University of California Los Angeles (UCLA).

Key research questions
- How can singly substituted and doubly substituted isotopologues of CH4 augment mixing ratios for understanding global fluxes of methane?
- How can sufficient CH4 be quantitatively removed from ambient air samples to study the rarer isotopologues?
- Are ambient air sample measurements reproducible and sufficiently precise to help us inform global CH4 fluxes?
- How do isotopic measurements from air samples align with models, based on specific historical and current emission scenarios?

Methodology
A global chemical transport model of the atmosphere will be the starting point to explore the distribution and trends in the major isotopologues of CH4. Source and sink magnitudes will be altered to understand the basic sensitivity of emissions to isotopic composition change. A Bayesian inversion system will then be constructed using model output (sensitivities); what is understood of isotopic source and sink signatures and emission magnitudes (apriori); and the atmospheric trends (measurements). This will be used to rigorously understand how isotopes can further constrain the possible emission source and sink magnitudes and direct a sampling campaign. During an 18-month placement at NPL large-volume CH4 sampling methods will be developed that will allow the study of the rare isotopologues in the global atmosphere. This placement will include collaboration with partners at UCLA to use the collected samples in a new high resolution mass spectrometry technique, ultimately improving our understanding of the current rapid changes in the global CH4 burden.

Training
A comprehensive training programme will be provided comprising both specialist scientific training and generic transferable and professional skills. You will receive support in data analysis and programming, and use of atmospheric transport models. The Global Change Research Institute (GCRI) within the School of GeoSciences provides an environment for collaborative engagement in a wider Earth system modelling community. And the National Physical Laboratory has a purpose built facility for training postgraduate
students (www.npl.co.uk/pgi/). Your experience at the interface of measurement and modelling science in a policy relevant discipline will provide you with a firm knowledge foundation in which to apply for postdoctoral training, or employment in industry or government.

**Requirements**

Motivation to work in a multidisciplinary environment, requiring communication within a large field of collaborative scientists. Experience or interest in laboratory methods for measuring greenhouse gases is desirable. Experience in computer programming is not essential from the start, however, an enthusiasm and ability to learn ‘on the job’ is required.

**Further reading**

Schaefer et al., A 21st-century shift from fossil-fuel to biogenic methane emissions indicated by $^{13}$CH$_4$ (2016) [doi: 10.1126/science.aad2705]

**Project summary**

Using atmospheric transport models, developing new sampling techniques, and utilising state-of-the-art measurement methods, this project explores isotopic composition of CH$_4$ to help solve both fundamental and policy relevant issues.