**What has driven the increase in atmospheric methane concentrations since 1750?**

*David Stevenson (School of GeoSciences, The University of Edinburgh; dstevens@staffmail.ed.ac.uk) and Fiona O'Connor (Met Office Hadley Centre)*

Global mean atmospheric methane concentrations have increased from about 700 ppb in 1750 to over 1800 ppb in 2015, with significant variations in growth rate – Figure 1 shows data from Hawaii for the last 27 years. A major driver of this increase has been the growth in a diverse range of anthropogenic methane emissions (e.g., from rice cultivation, ruminants, and industrial activities). However, there have been several other important influences on methane. Natural emissions of methane (O'Connor et al., 2010), such as those from wetlands (both tropical and high-latitude), have probably changed, partly due to climate change (via changes in temperature, precipitation, and soil carbon). The main sink of atmospheric methane is oxidation by the hydroxyl radical (OH). Rising anthropogenic emissions of nitrogen oxides have tended to increase OH, whilst anthropogenic emissions of carbon monoxide and hydrocarbons (including methane) have tended to decrease OH (e.g., Stevenson et al., 2013; Naik et al., 2013). Changes in natural emissions of these species have probably also affected OH levels. The primary source of atmospheric OH is water vapour; increases in water vapour associated with climate warming have tended to increase OH. A further control on OH is ultra-violet (UV) radiation, as several photolysis reactions affect OH. Changes in stratospheric ozone have affected UV and hence OH. Changes in aerosol and cloudiness are further potential contributors to changes in UV and OH.

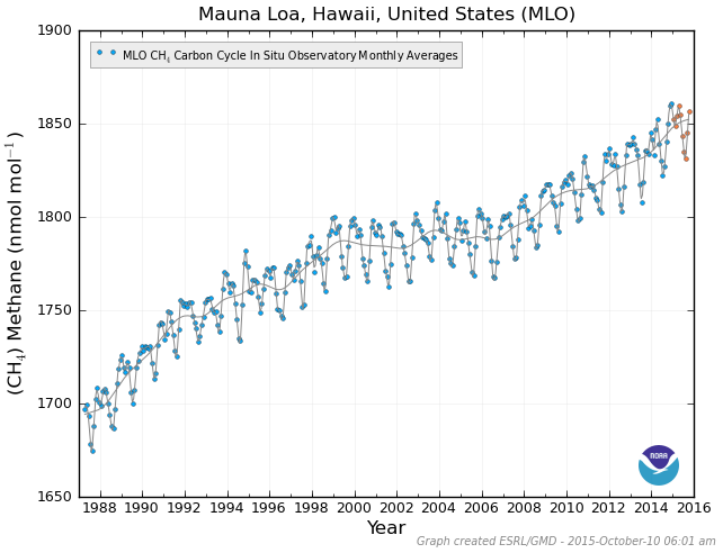


***Figure 1:*** *Atmospheric methane (monthly mean, in-situ data) measured at Mauna Loa, 1987-2015 (data from [http://www.esrl.noaa.gov/gmd/](http://www.esrl.noaa.gov/gmd/))*

This PhD project aims to explore all of these factors, using a wide variety of observations and models. Central to the project will be the application of an Earth System Modelling approach, and we will use the joint Met Office/NERC ESM, UKESM1, incorporating the UKCA atmospheric chemistry and aerosol model (see [http://www.ukca.ac.uk](http://www.ukca.ac.uk), O'Connor et al., 2013). Training and support will be offered in the use of these complex models. A comprehensive training programme will be provided comprising both specialist scientific training and generic transferable and professional skills. Although this studentship is not a CASE studentship with additional financial support from the Met Office, part of the student's time will be spent at the

Met Office, where the co-supervisor will provide advice concerning modelling, including experimental design and data analysis.

The first few months of the project will be spent reading, summarising and synthesizing the relevant scientific literature, in conjunction with training in the use of the model, assembling useful observational datasets and designing and performing initial model experiments. The various factors affecting methane described above will then be individually investigated in a consistent modelling framework – designing, analysing and refining these experiments will take most of the available time. Throughout the project, the student will be expected to write and publish their results in the scientific literature and present results at national and international science meetings.

The ideal candidate will have a quantitative science/engineering/computing background, and a strong interest in atmospheric/Earth system science. Prior experience with atmospheric or Earth system modelling or data analysis is not essential.

**References**

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O'Connor, F. M., et al. (2013) Evaluation of the new UKCA climate-composition model – Part 2: The Troposphere, Geosci. Model Dev. Discuss., 6, 1743-1857, doi:10.5194/gmdd-6-1743-2013. (http://www.geosci-model-dev-discuss.net/6/1743/2013/gmdd-6-1743-2013.html)

Stevenson, D. S., et al. (2013) Tropospheric ozone changes, radiative forcing and attribution to emissions in the Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP), Atmos. Chem. Phys., 13, 3063-3085, doi:10.5194/acp-13-3063-2013. (http://www.atmos-chem-phys.net/13/3063/2013/acp-13-3063-2013.html)

**30-word project summary for advertising:**

Atmospheric methane has tripled since 1750. Why? Growing emissions are one driver. Changes in its atmospheric sink are the other. Models and measurements will be used to quantify methane's budget.