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Quantifying methane emissions from fossil fuel sources using a Bayesian inverse model and observations of ethane with an uncertain emissions ratio

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Methane is an important greenhouse gas with a range of anthropogenic sources, including livestock farming and fossil fuel production. It is important that methane emissions can be correctly attributed to their source, to aid climate change policy and emissions mitigation efforts. For source attribution, many 'top-down' models of atmospheric methane use spatial maps of sources from emissions inventory data coupled with an atmospheric transport model. However, this can cause difficulties if sources are co-located or if there is uncertainty in the sources' spatial distributions.

To help with this issue and reduce overall uncertainty in estimates of methane emissions, recent methods have used observations of a secondary trace gas and its correlation with methane to infer methane emissions from a target sector. Most previous work has assumed a fixed emissions ratio between the two gases, which often does not reflect the true range of possible emission ratios. In this work, measurements of atmospheric ethane and its emissions ratio relative to methane are used to infer emissions of methane from fossil fuel sources. Instead of assuming a fixed emission ratio, our method allows for uncertainty in the emission ratio to be statistically propagated through the inverse model and incorporated into the sectoral estimates of methane emissions. We further demonstrate the inaccuracies that can result in an assessment of fossil fuel methane emissions if this uncertainty is not considered.

We present this novel method for modelling sectoral methane emissions with examples from a synthetic data experiment and give results from a case study of UK methane emissions. Methane and ethane observations from a tall tower network across the UK were used with this model to produce monthly estimates of UK fossil fuel methane emissions with improved uncertainty characterisation.