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Evaluation of inverse models to estimate methane emissions from European countries

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Methane is a powerful greenhouse gas that is a major contributor to climate change. Quantifying emissions by process is therefore important, especially as many countries (including most European countries) have pledged to drastically reduce their emissions through the Global Methane Pledge and regional regulations. These countries report their emissions annually to the UNFCCC through National Inventory Documents (NIDs).

While reported emissions are estimated using established methods based on bottom-up activity data, the UK and Switzerland additionally include in their NIRs an assessment using atmospheric observations. This independent assessment is derived using atmospheric inverse modelling or "top-down" methods. The Horizon Europe project Process Attribution of Regional emISsions (PARIS) extends "top-down" comparisons with inventories to several additional European countries.

In this work, we carry out a sensitivity analysis of methane inversions over Europe from 2018 to 2023. This enables us to first assess the influence of different inversion parameters, such as the number of sites, the transport model, estimation of boundary conditions, and the role of data filtering and model uncertainty. We thus evaluate our confidence in European methane inversions and identify the main parameters that lead to discrepancies between inversions. Two transport models: NAME and FLEXPART; and three inversion models: ELRIS from Empa, InTEM from MetOffice and RHIME from the University of Bristol are used.

We then focus on a 35 year assessment of methane emissions over the UK over the period (1989-2023) using RHIME and InTEM, thus re-evaluating the emissions reported by the UK over the last few decades using two different inversion models. The RHIME and InTEM estimates are broadly in agreement, however, both estimate significantly lower emissions than those reported in the latest UK NIR for the 1990s and early 2000s. Although fewer sites were available on the 1989-2000 period than in the years covered in the PARIS project, the use of two inversion methods provides additional confidence that a large disagreement between atmospheric measurements

and the UK inventory exists until the early 2000s.