Spatial and personalised estimates of slurry methane emissions

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Introduction

- 16% of agricultural greenhouse gas emissions in the UK are from manure (mostly methane)
- Mitigating these emissions usually have no effect on production.
- Temperature is a major driver for slurry methane emissions (Figure 1b).
- Differences in climate cause variations in these emission, and global warming may accelerate emissions.
- The UK Greenhouse Gas Inventory uses a constant emissions multiplier for slurry methane, regardless of the climate.
- Here we develop a model to estimate slurry methane emissions across the UK using spatially resolved historic climate data with the aim of investigating effects of climate change and developing appropriate emission estimates for each nation of the UK.

Methods

- Model inputs: daily data on slurry generation (number of animals, milk yield, time spent indoors) and monthly average air temperature (Met Office's HadUK-Grid).
- Spatial resolution: 25 km grid.
- The model is based on IPCC equations, except for slurry methane emissions where air temperatures are used to determine slurry temperatures (Fig 1a) which in turn determines the rate of methane production (Fig 1b). The rate of slurry generation and rate of methane production are used as inputs into a system of ordinary differential equations which determines slurry methane production.

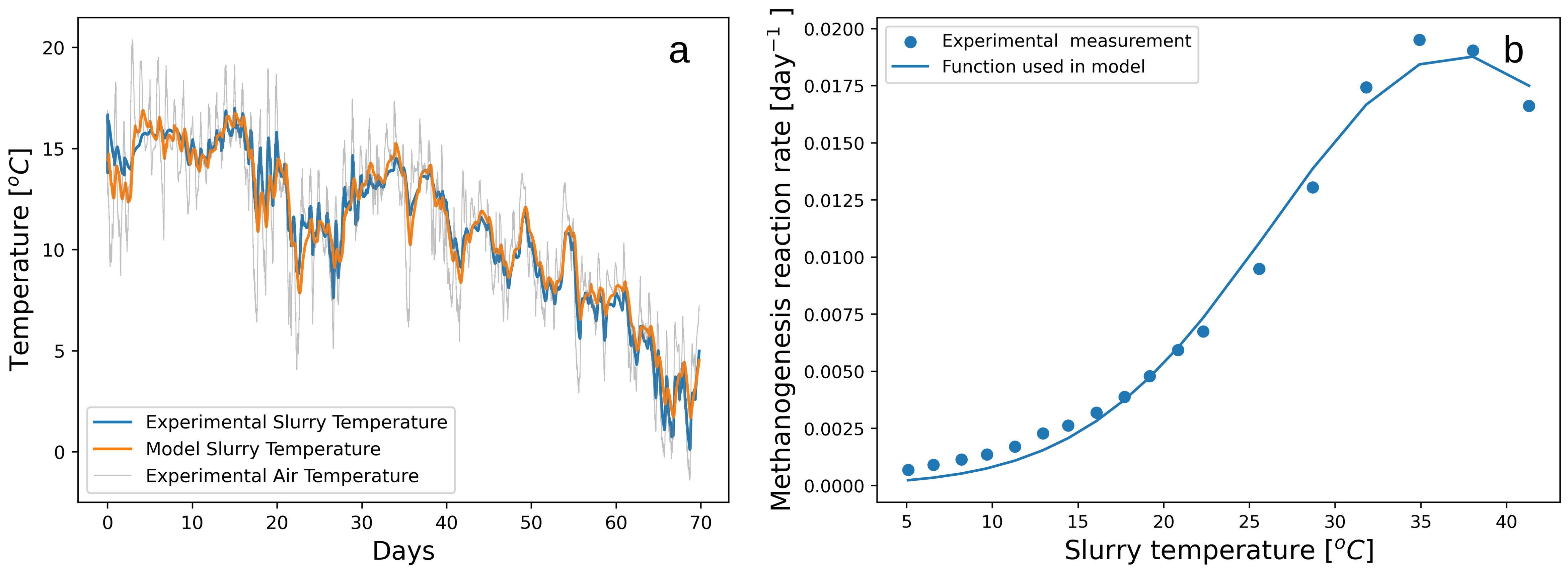

Figure 1: Ingredients in the model used for estimating spatial slurry methane emissions a) Calculating slurry temperature based on local air temperatures (experimental data from Misselbrook (2016)); b) Calculating the rate of methane production as a function of slurry temperature (experimental data from Elsgaard (2016)).

Results

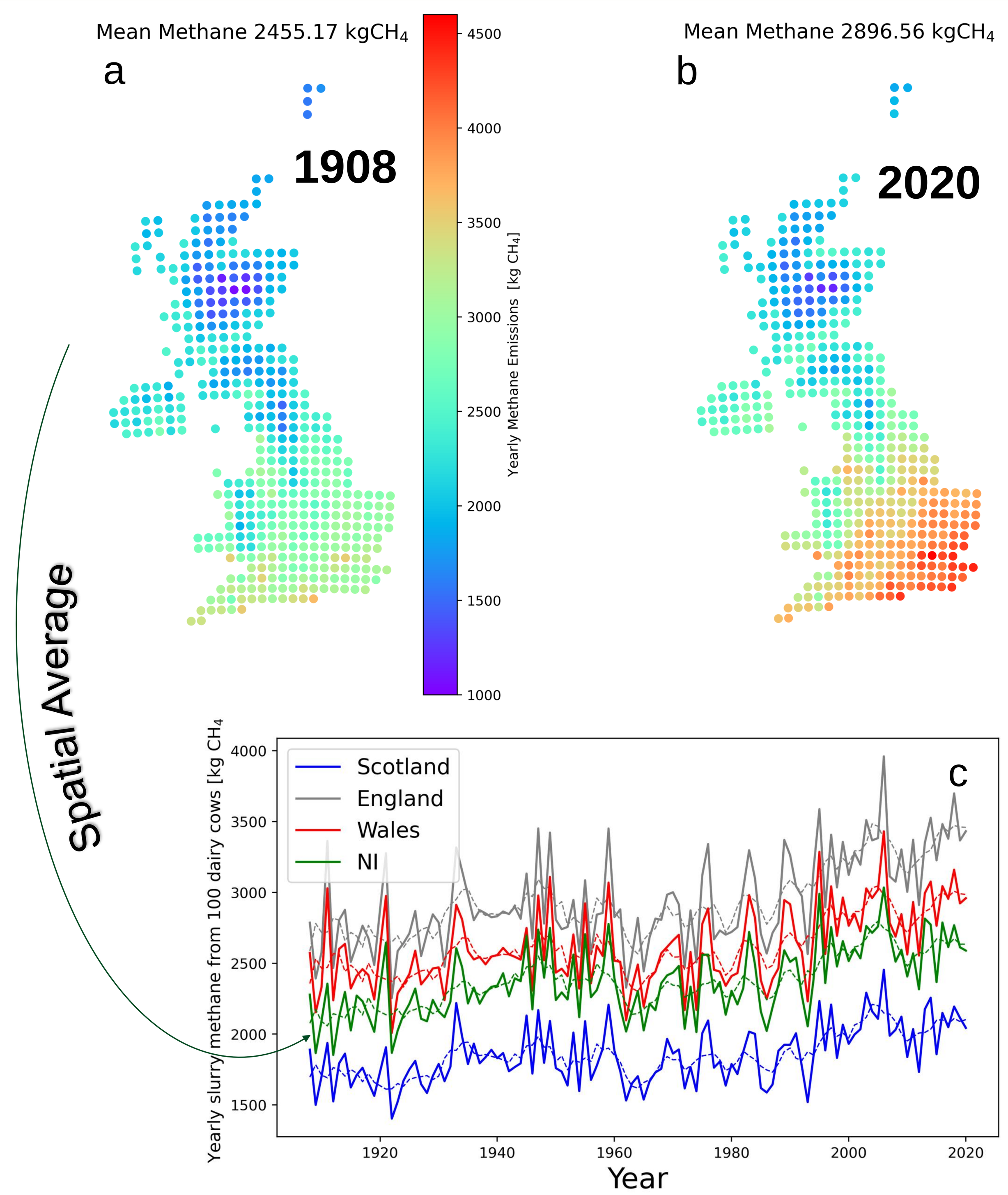

Figure 2: Total slurry methane produced from Jan-Dec assuming each grid point contains 100 dairy cows a) 1908 and b) 2020 ; c) The average total slurry methane produced in each nation. Dashed lines show rolling mean.

Figure 2 show hypothetical slurry methane emissions assuming all else but temperature is equal in the grid, therefore the maps to not account for the distribution of livestock. The model simulates the generation of slurry throughout the year, assuming the cows are housed during winter months. Emissions are heterogeneous throughout the UK due to differences in temperatures. For example, a 100-cow dairy farm in Ayrshire in 2020 would produce 2200kg CH_4 from slurry, while in Kent it would produce 4500kg CH_4 according to the model. Emission rates vary throughout the year due to differences in slurry volumes and temperatures, for example the mean rate in Mach 2020 was 2kg CH_4/day while in August it was 22kgCH_4/day (results not shown)

Conclusions

- Slurry methane emissions are not equal across the UK.
- Most emissions occur when slurry volume and temperature are high. Targeting mitigation methods (e.g. acidification) or anaerobic digestion over the hot periods could significantly reduce methane emissions. This can be particularly important for indoor systems.
- There is evidence of the effect of global warming on slurry methane emissions, particularly in the south of England.
- The model can be used to make personalised estimates of emissions based on local climate data to guide best practices.

Acknowledgements

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Refs: Misselbrook (2016): doi.org/10.2134/jeq2015.12.0618; Elsgaard (2016): doi.org/10.1016/j.scitotenv.2015.07.145