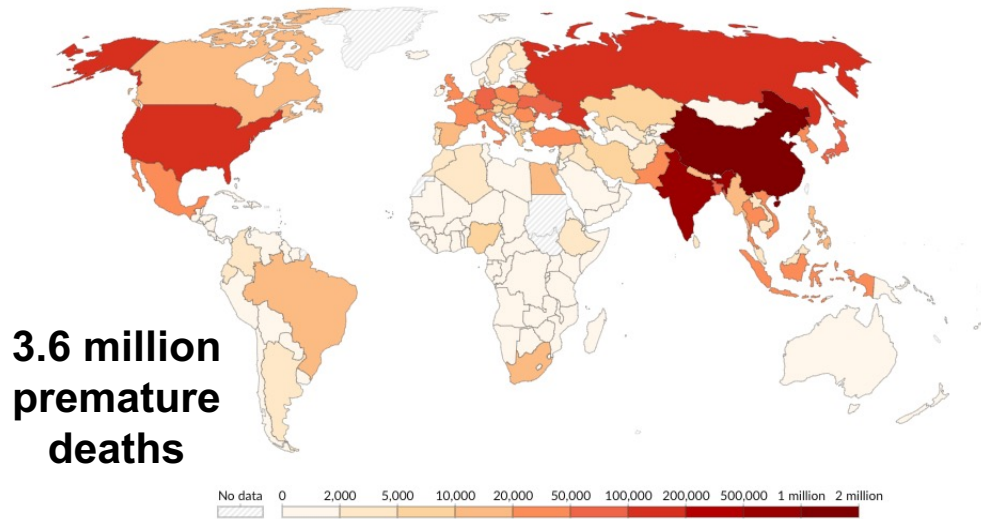


Global health burden of ammonia emissions from fossil-fuel derived synthetic nitrogen fertilizer

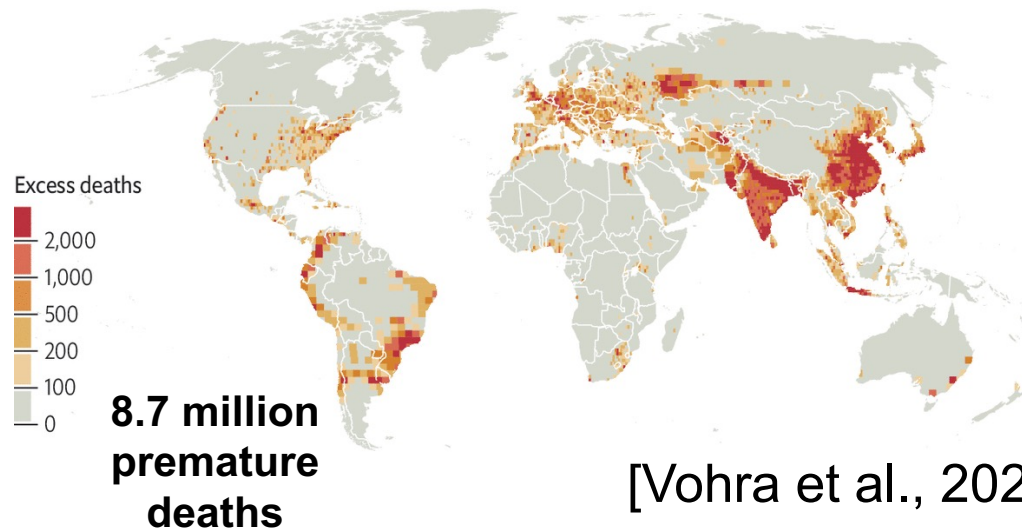


Karn Vohra (k.vohra@ucl.ac.uk) with contributions from Eloise Marais, Bex Horner, Colin Harkins, Brian McDonald, Aaron Cohen, Aaron van Donkelaar and Randall V. Martin **IGC11** 11 June 2024

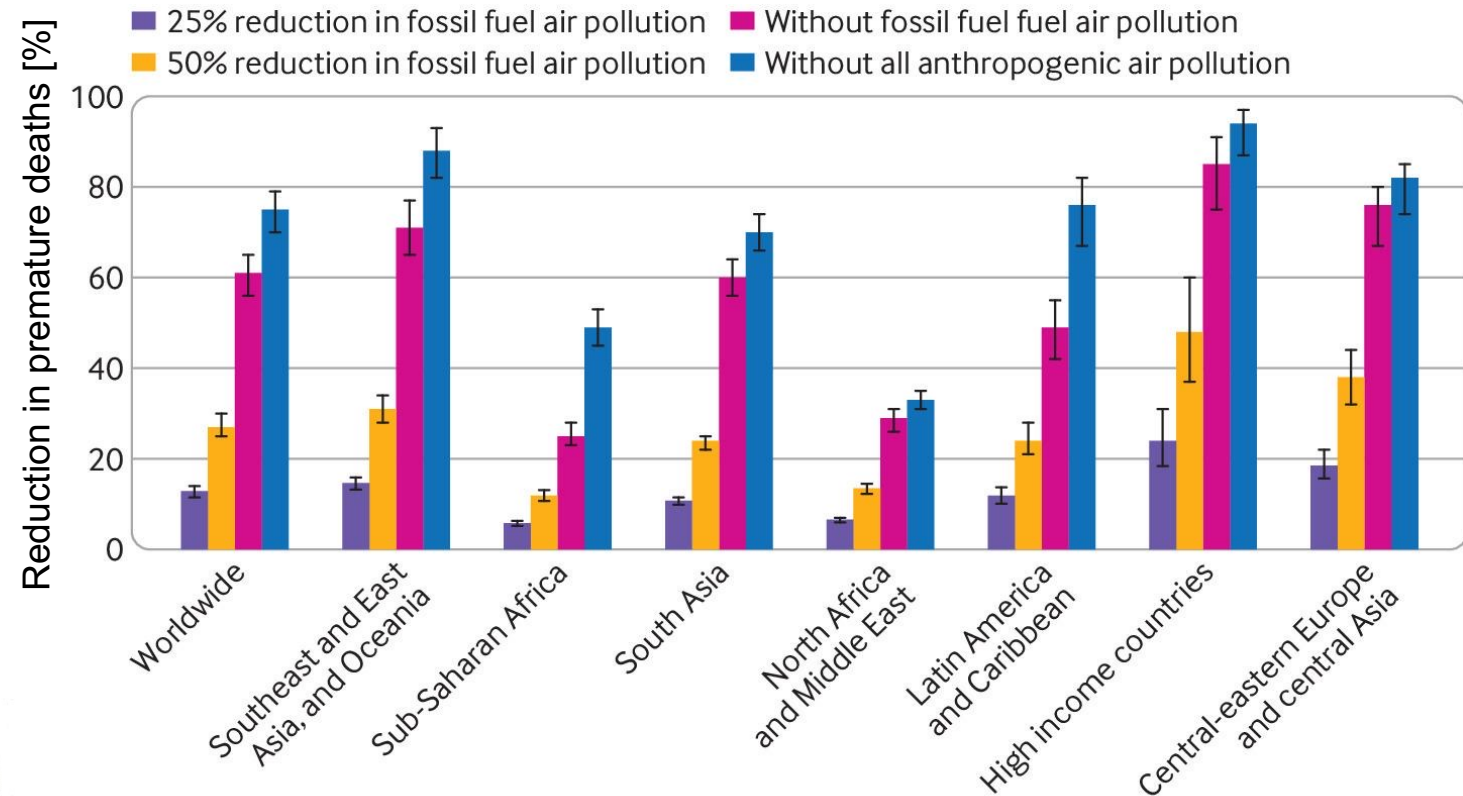
End-use health burden assessments focus only on fossil fuel combustion



[Lelieveld et al., 2019]

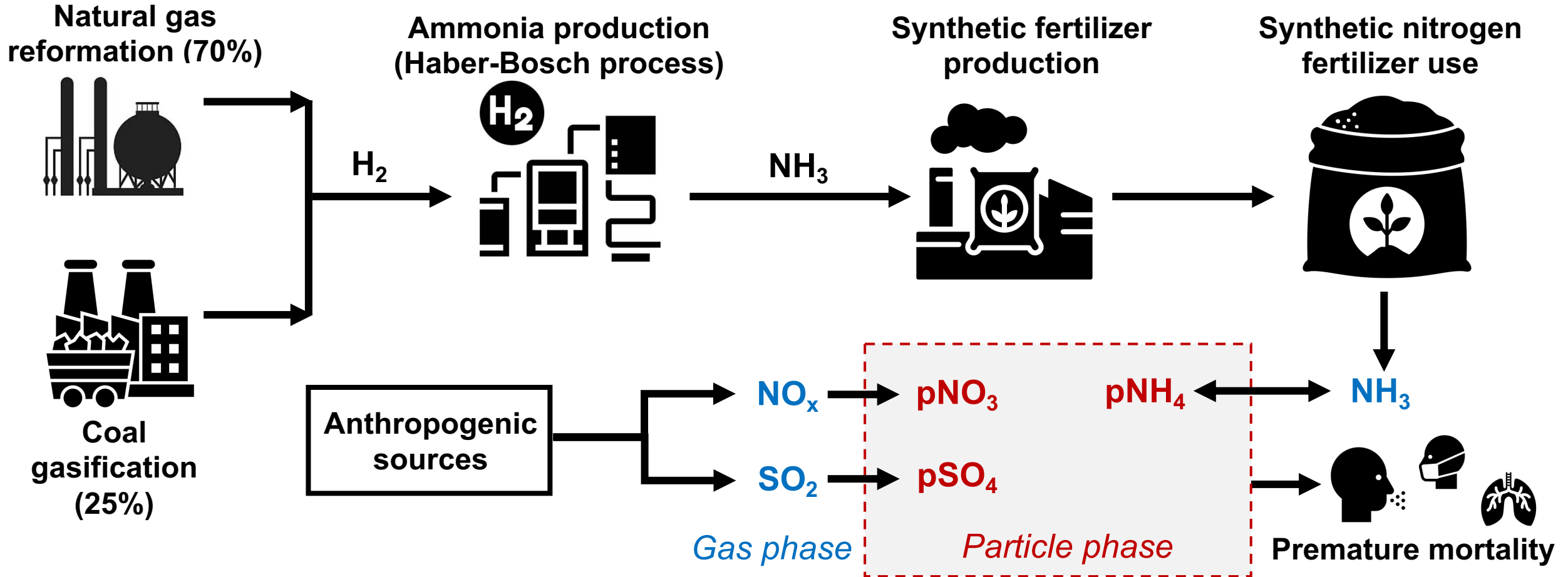


[Vohra et al., 2021]



[Lelieveld et al., 2023]

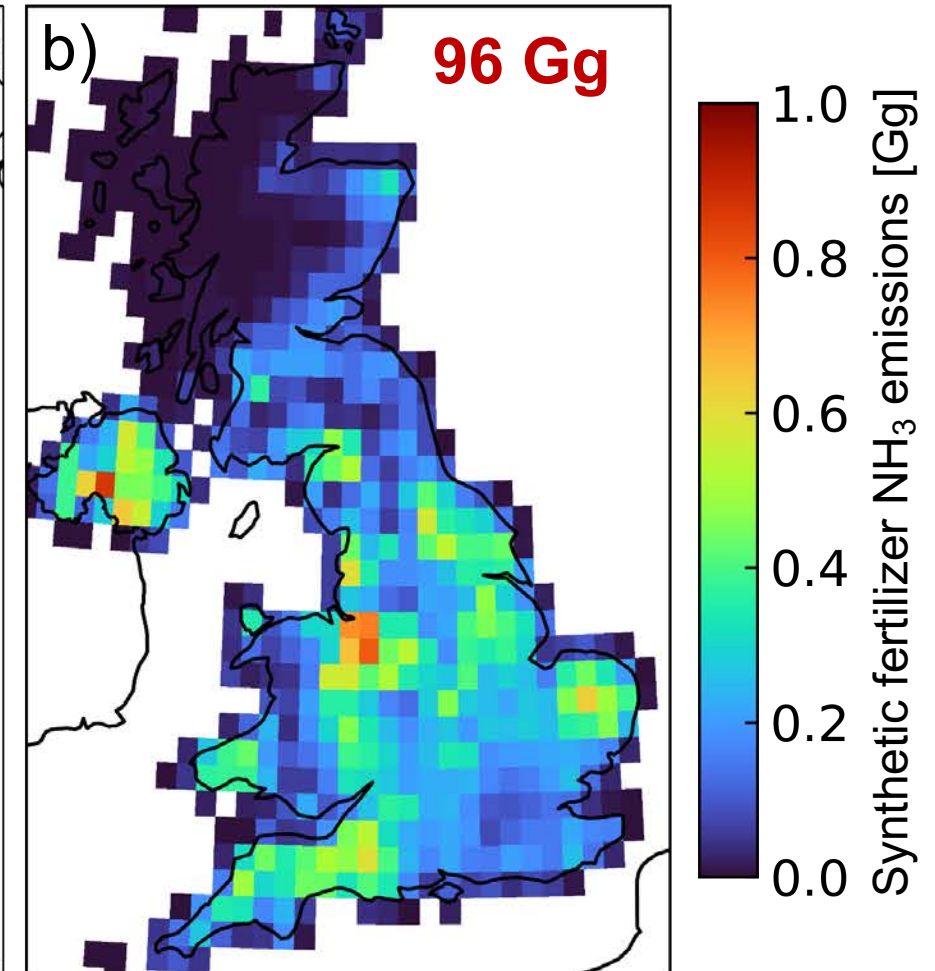
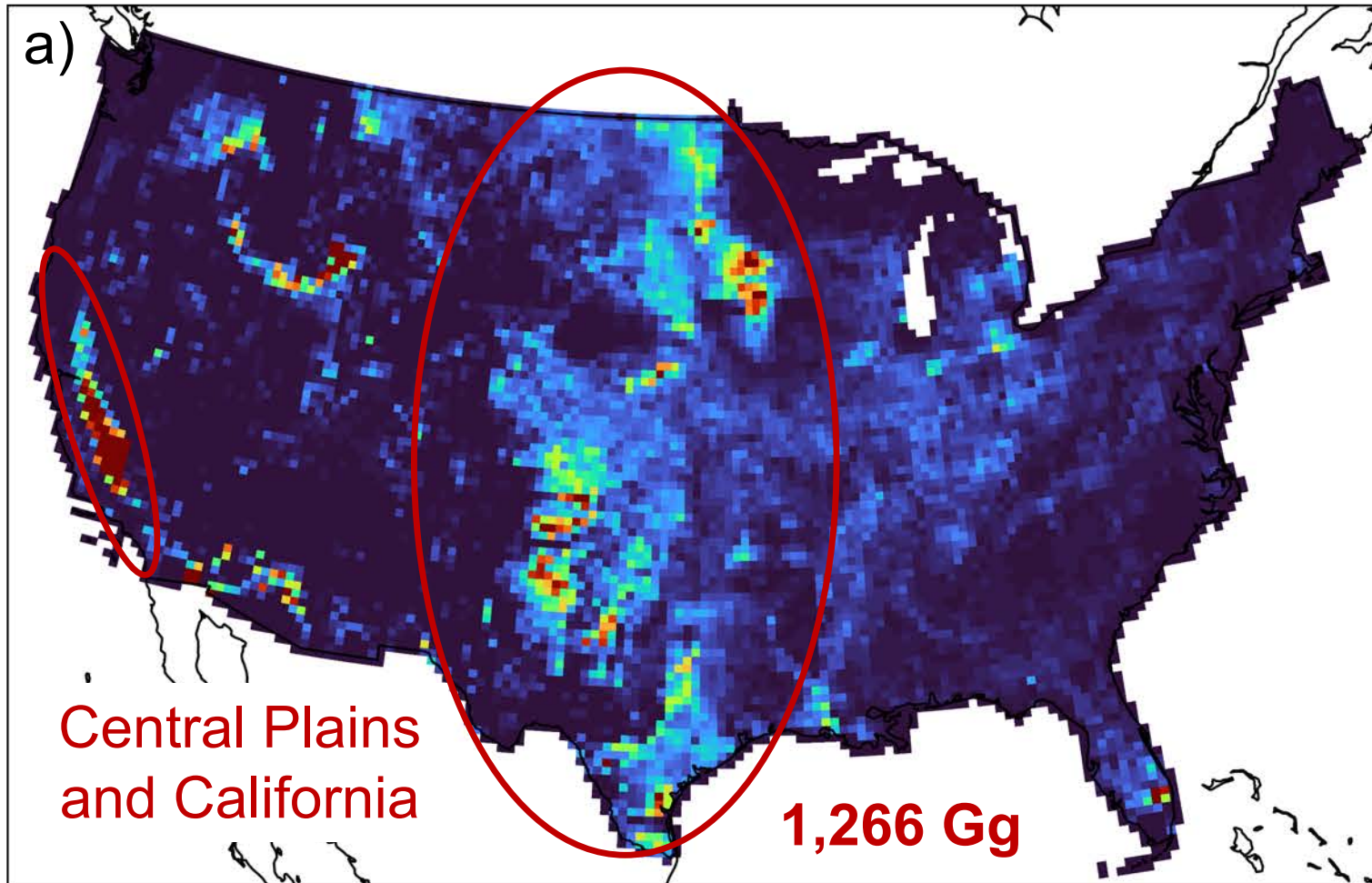
Synthesis of nitrogen fertilizers from fossil fuels



This end-use activity missing in global health burden assessments!

NH₃ emissions from synthetic nitrogen fertilizer

Challenges: Lumped with livestock, at coarse spatiotemporal resolution and outdated

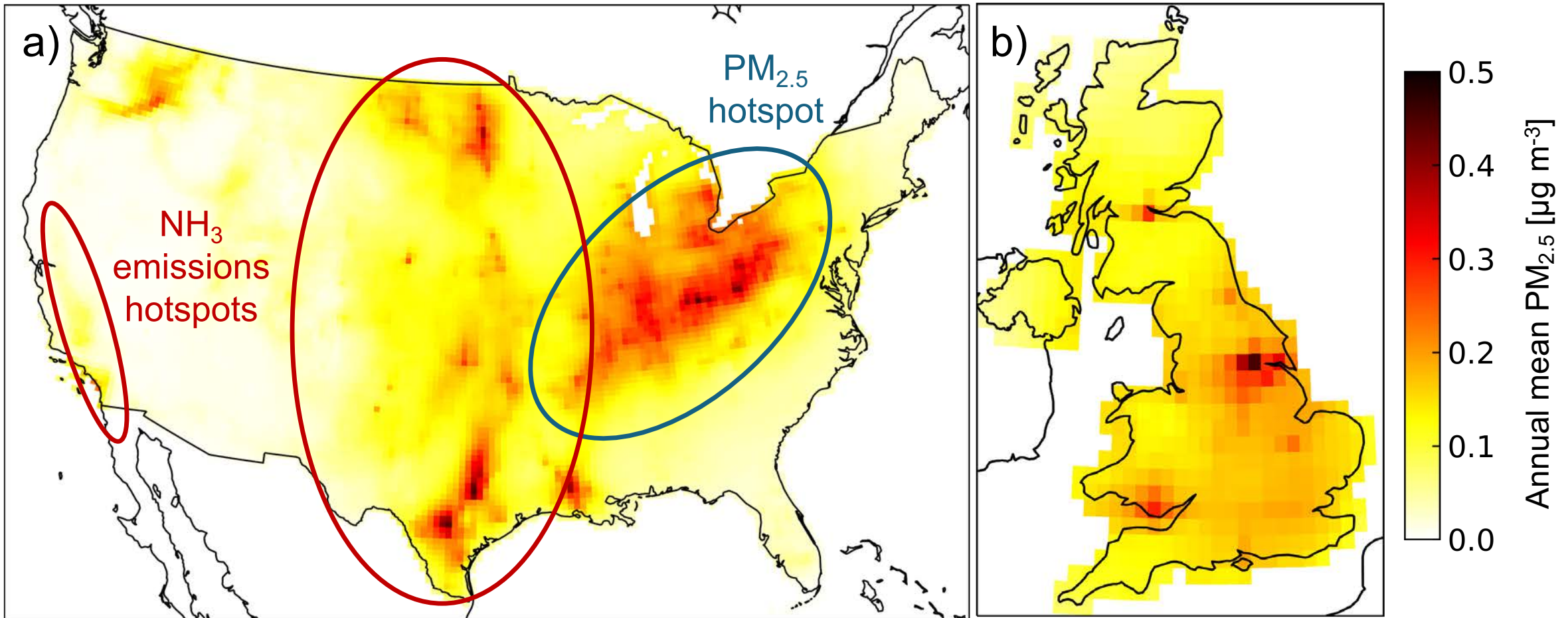


US EPA National Emissions Inventory 2017 species: NH₃_Fert
[Data processed by Brian McDonald and Colin Harkins]

Agricultural NH₃ emissions from UK National
Atmospheric Emissions Inventory 2019 and
fertilizer contribution from Paulot et al. (2014)

PM_{2.5} linked to synthetic nitrogen fertilizer NH₃ emissions

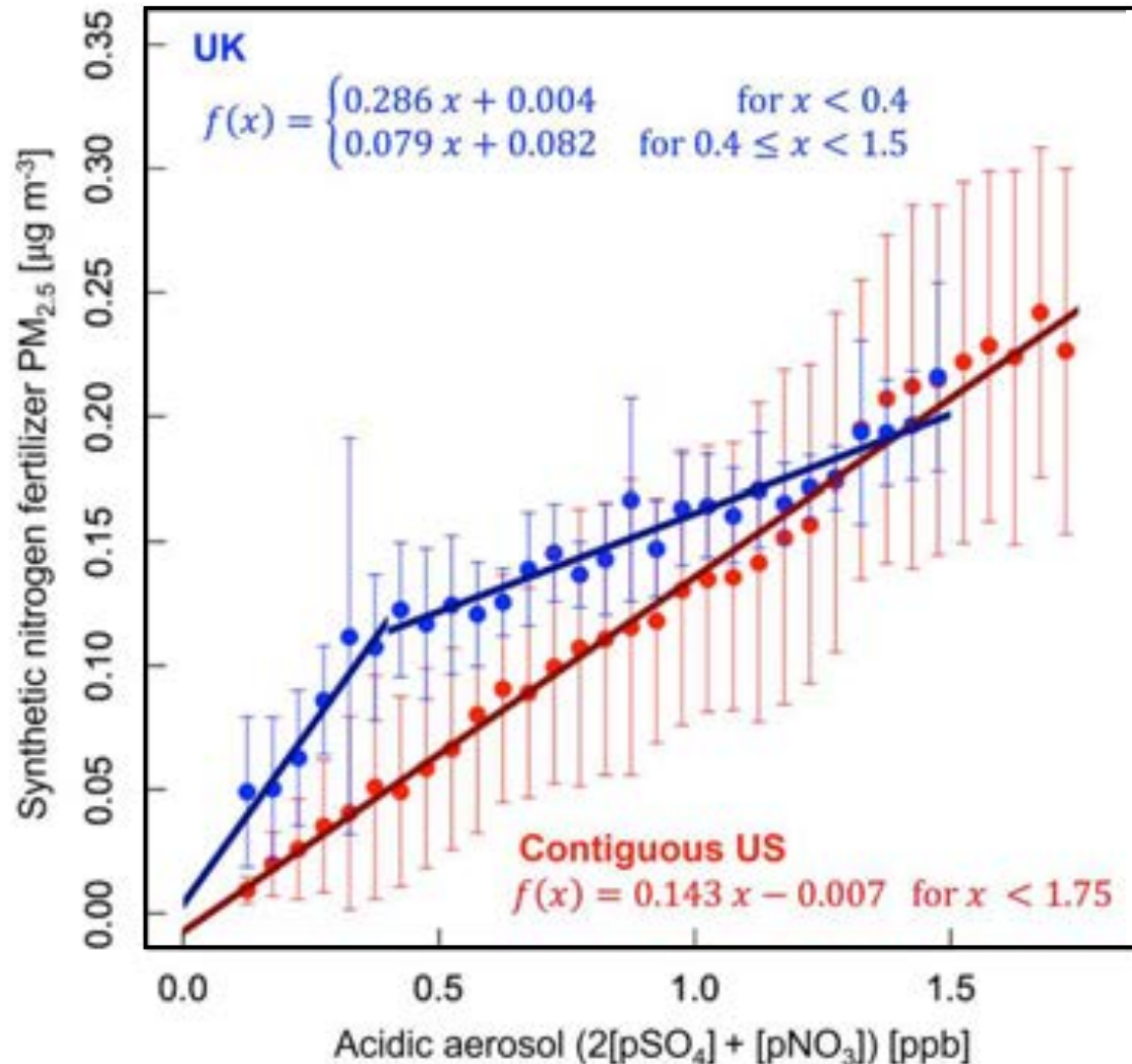
We run GEOS-Chem with and without these NH₃ emissions at 0.25°×0.3125° resolution



A major factor influencing PM_{2.5} formation is acidic aerosol abundance. Temperature and relative humidity also influence partitioning of semi-volatile NH₃.

Acidic aerosols and synthetic nitrogen fertilizer PM_{2.5}

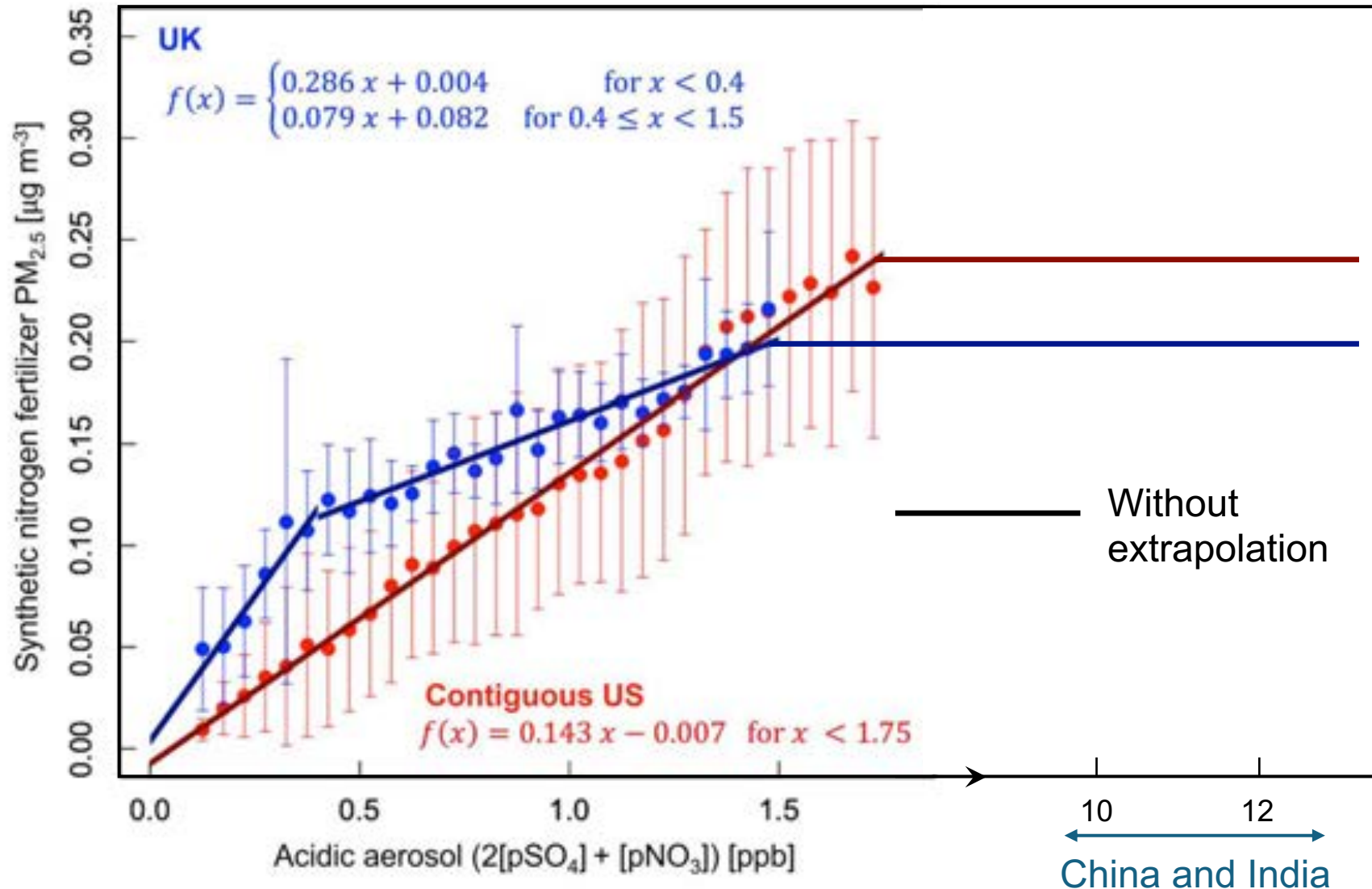
NH₃ uptake to aerosol phase is limited by acidic aerosol abundance [Tang et al., 2018, Walker et al., 2004]



We use UK and US simulations to parameterise relationship between synthetic nitrogen fertiliser PM_{2.5} and acidic aerosols to extend to other countries

Acidic aerosols and synthetic nitrogen fertilizer PM_{2.5}

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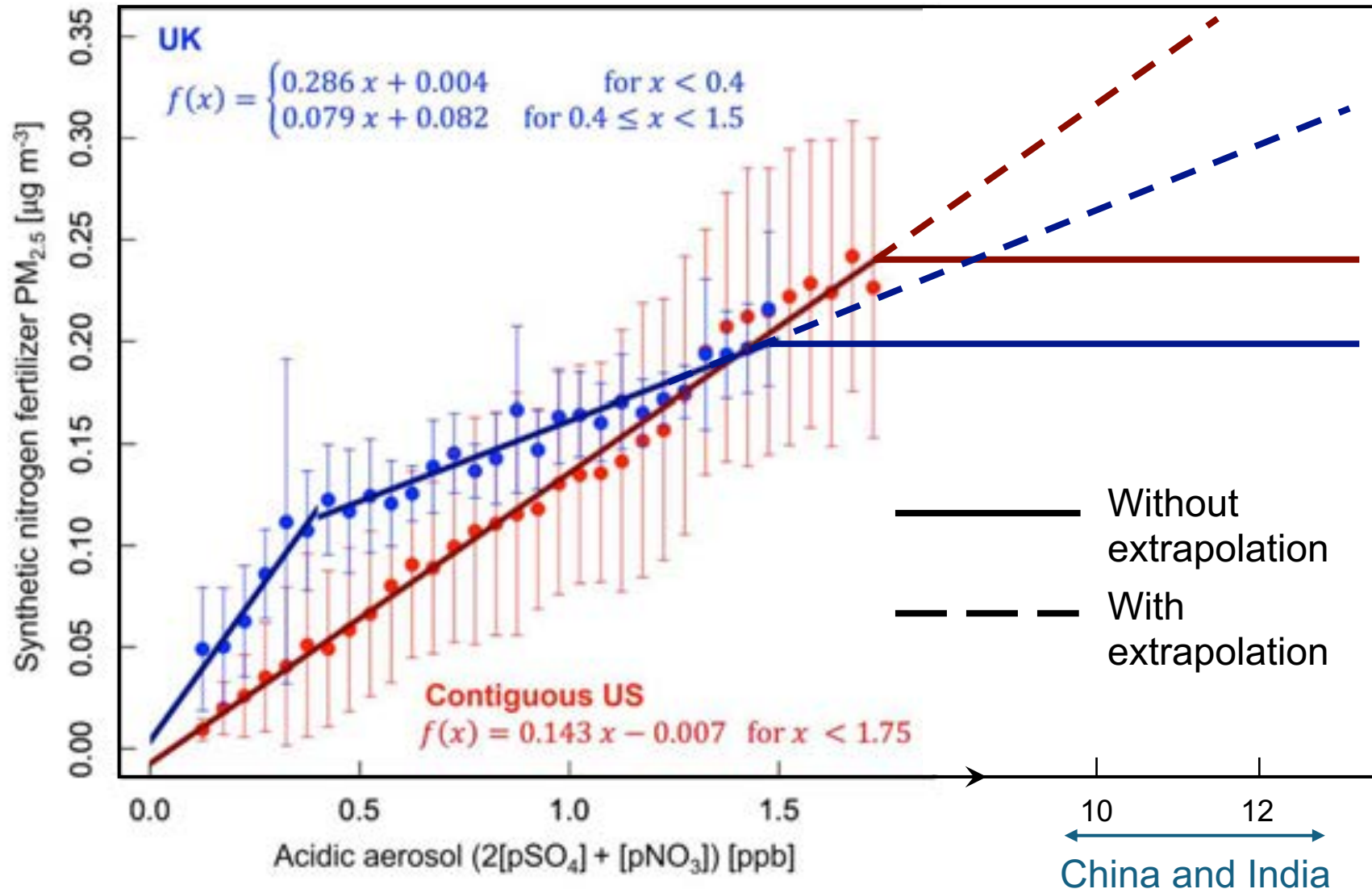


We use UK and US simulations to parameterise relationship between synthetic nitrogen fertiliser PM_{2.5} and acidic aerosols to extend to other countries

We consider scenarios where the relationship is restricted to maximum acidic aerosol abundance simulated by GEOS-Chem

Acidic aerosols and synthetic nitrogen fertilizer PM_{2.5}

NH₃ uptake to aerosol phase is limited by acidic aerosol abundance [Tang et al., 2018, Walker et al., 2004]

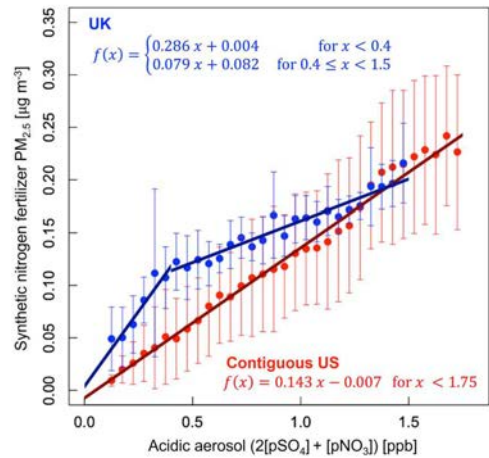


We use UK and US simulations to parameterise relationship between synthetic nitrogen fertiliser PM_{2.5} and acidic aerosols to extend to other countries

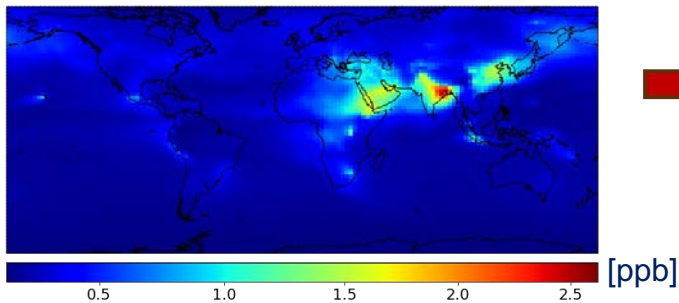
We consider scenarios where the relationship is restricted to maximum acidic aerosol abundance simulated by GEOS-Chem and when sustained beyond this threshold

Estimation of global PM_{2.5} exposure and attributable mortality

Relationship between acidic aerosols and synthetic nitrogen fertilizer PM_{2.5}

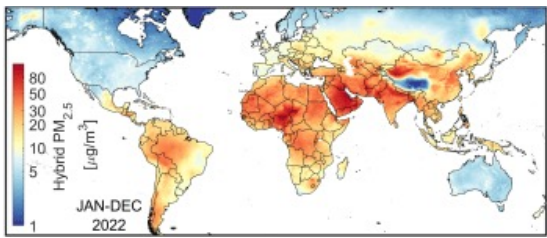


Acidic aerosol abundance from a global 2°×2.5° simulation



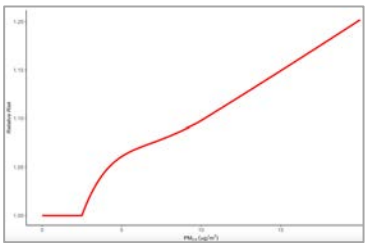
Global PM_{2.5} with and without synthetic nitrogen fertilizer use

Global PM_{2.5} from all sources [van Donkelaar et al., 2021]



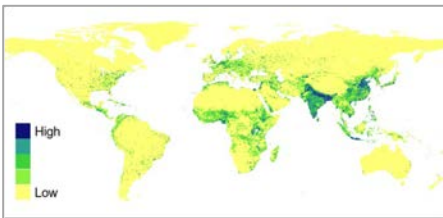
Global synthetic nitrogen fertilizer PM_{2.5}

Health impact function [Marais et al., 2023]

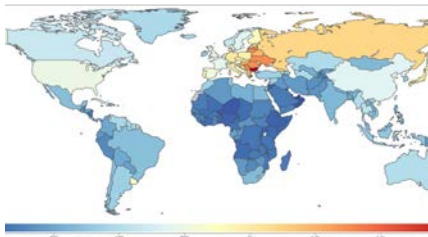


Population attributable fraction

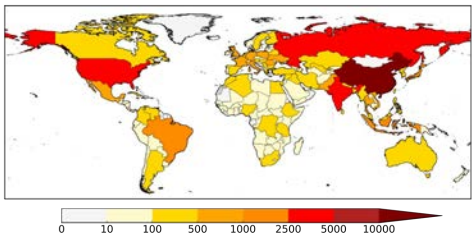
Global population from WorldPop



Baseline mortality rates from Global Burden of Disease



Global health burden of synthetic nitrogen fertilizer PM_{2.5}

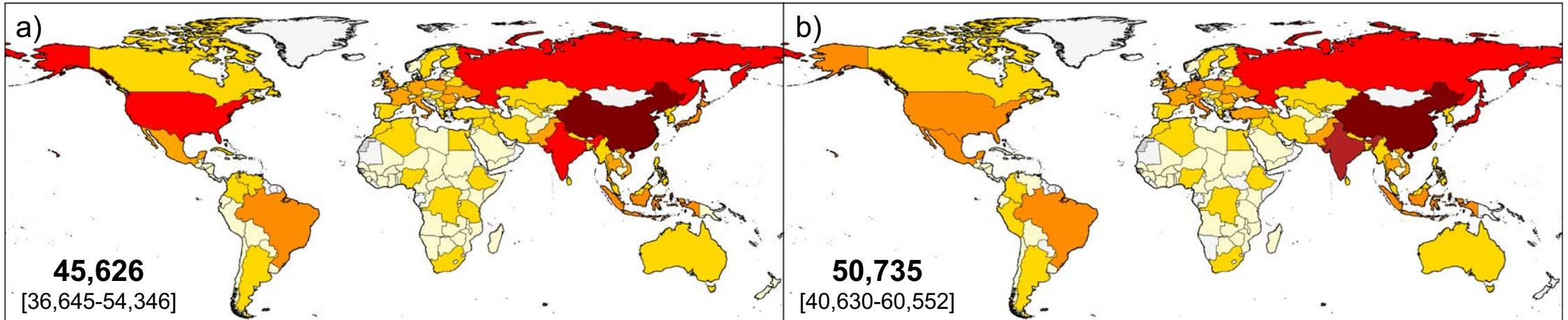


Global health burden of synthetic nitrogen fertilizer use

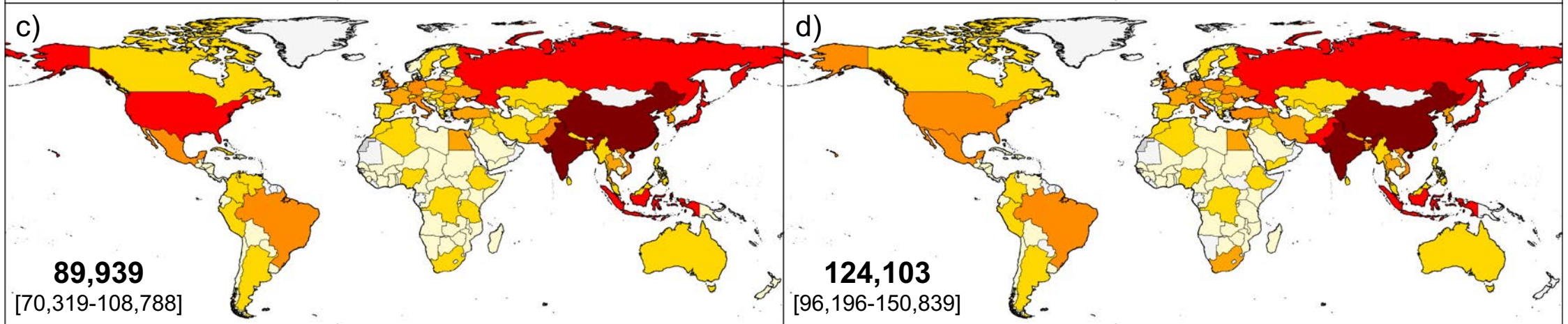
UK regression statistics

US regression statistics

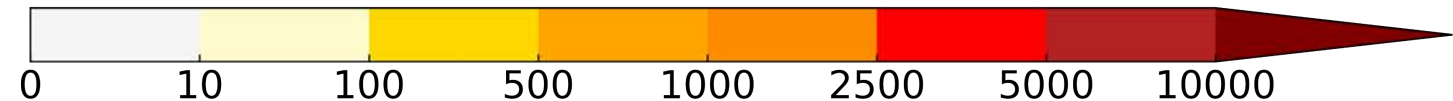
Without
extrapolation



With
extrapolation



Premature
deaths



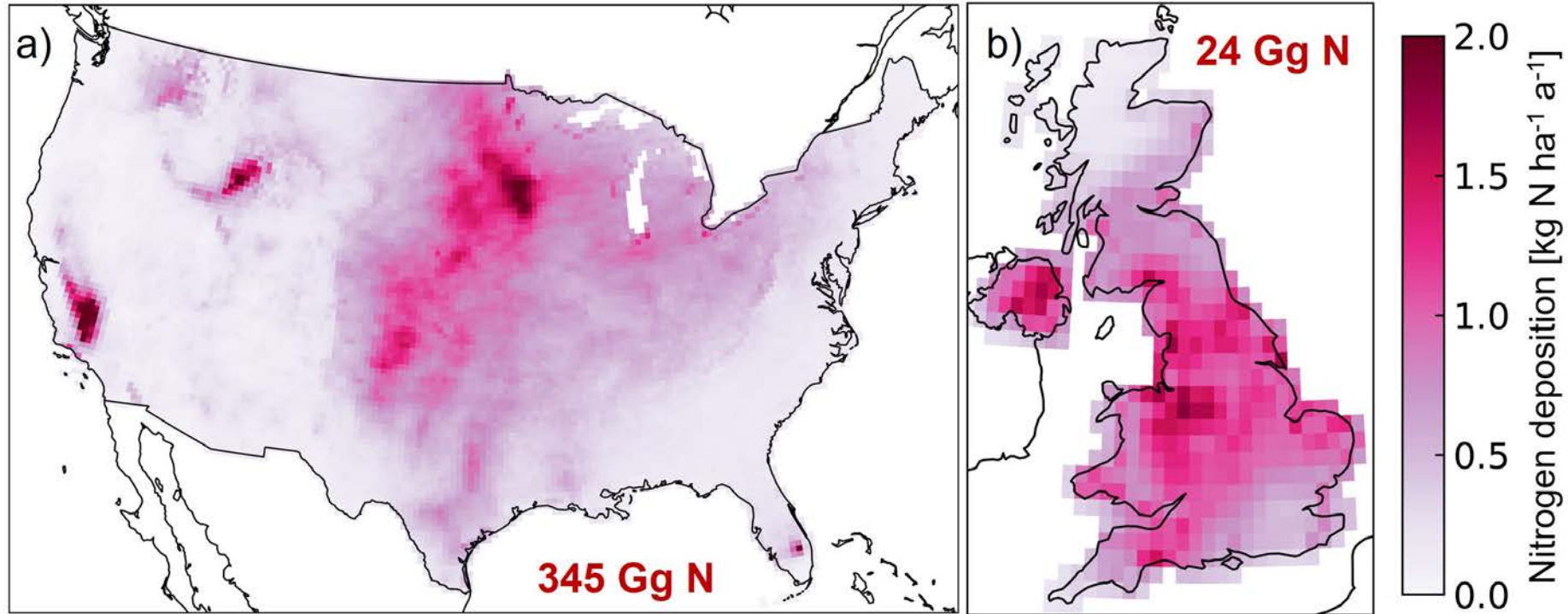
Our estimates represent up to 3% of fossil fuel end-use premature mortality burden

**China & India
account for
35-60% of total**

Key takeaways

- **45,000-124,000** global premature deaths linked to fossil fuel derived synthetic nitrogen fertilizer $\text{PM}_{2.5}$
- Policy interventions will mitigate premature mortality but not harm to nitrogen sensitive habitats

Nitrogen deposition from synthetic nitrogen fertilizer use



- Most effective to develop strategies that enhance nitrogen usage efficiencies
- Need for national inventories to separately report NH_3 emissions from fertilizer use to further refine the values we obtain

Any questions? Contact Karn (k.vohra@ucl.ac.uk)