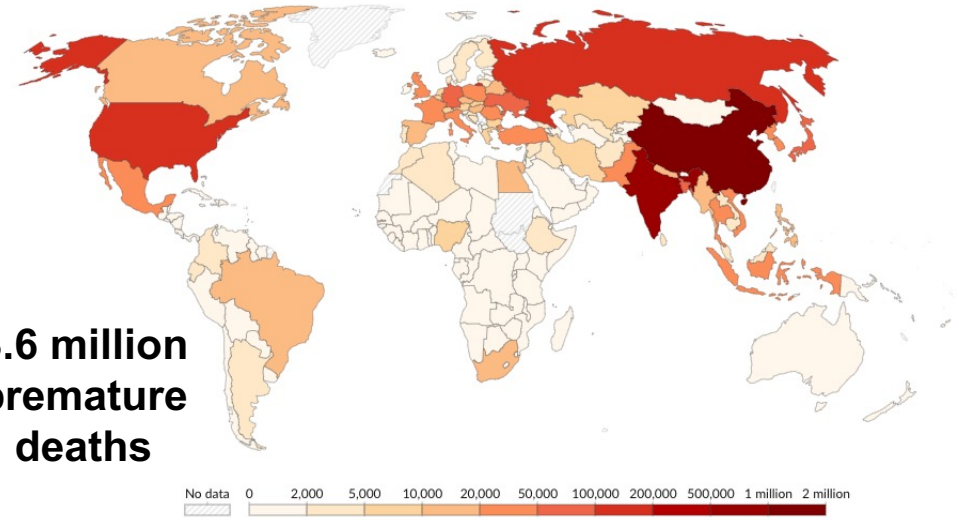
Global health burden of ammonia emissions from fossil-fuel derived synthetic nitrogen fertilizer

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

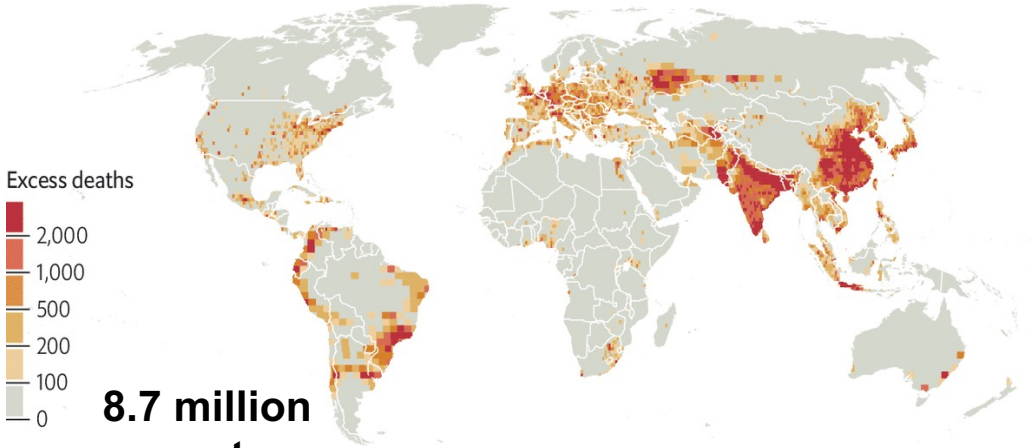
IGC11 11 June 2024

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



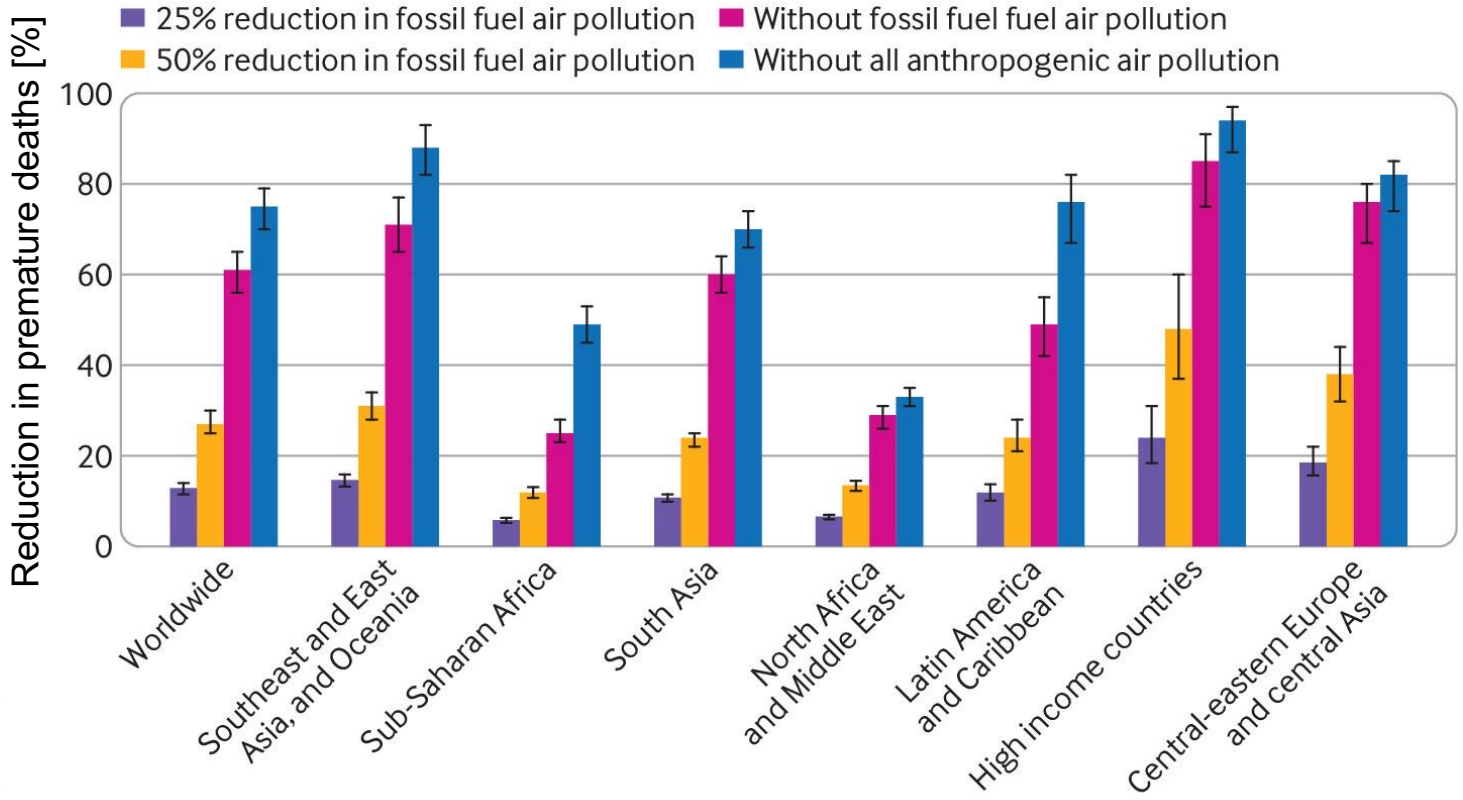
3.6 million premature deaths

[Lelieveld et al., 2019]



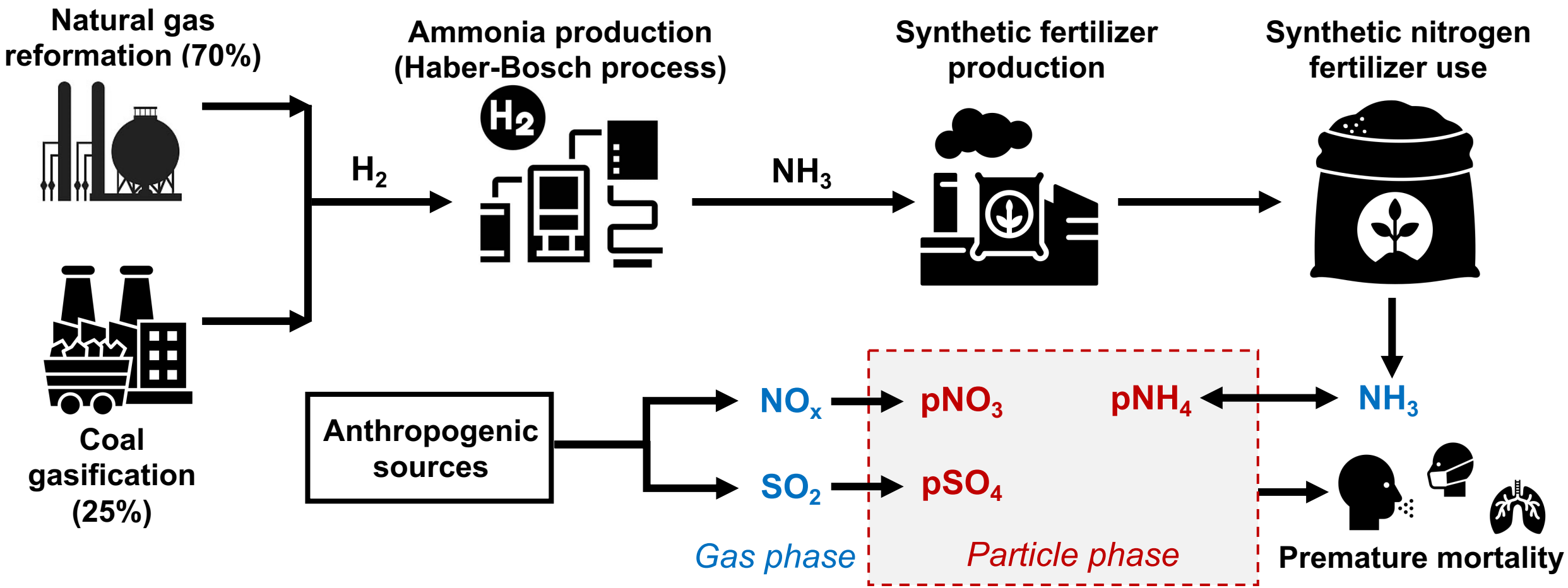
8.7 million premature deaths

[Vohra et al., 2021]



[Lelieveld et al., 2023]

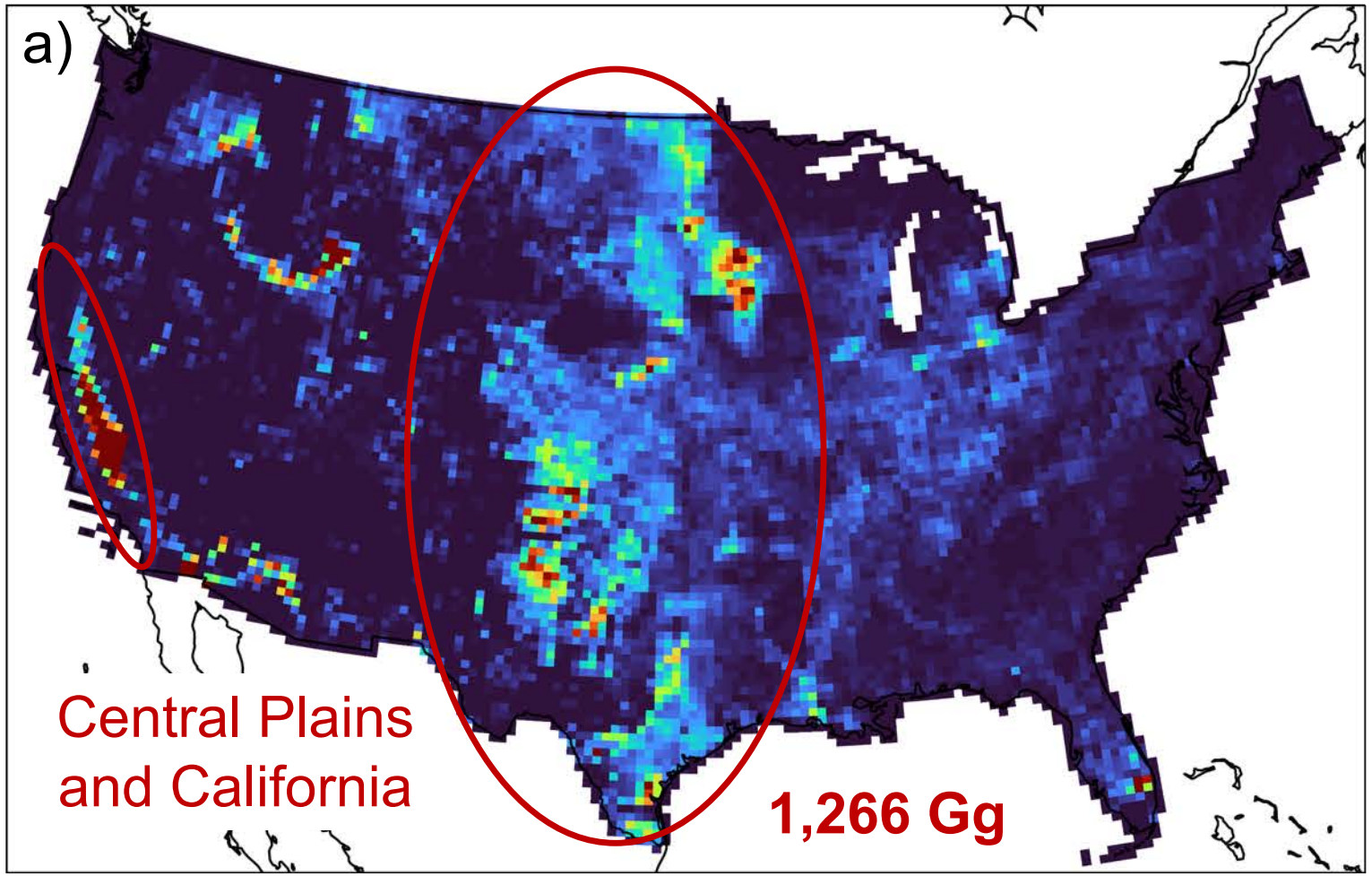
Synthesis of nitrogen fertilizers from fossil fuels

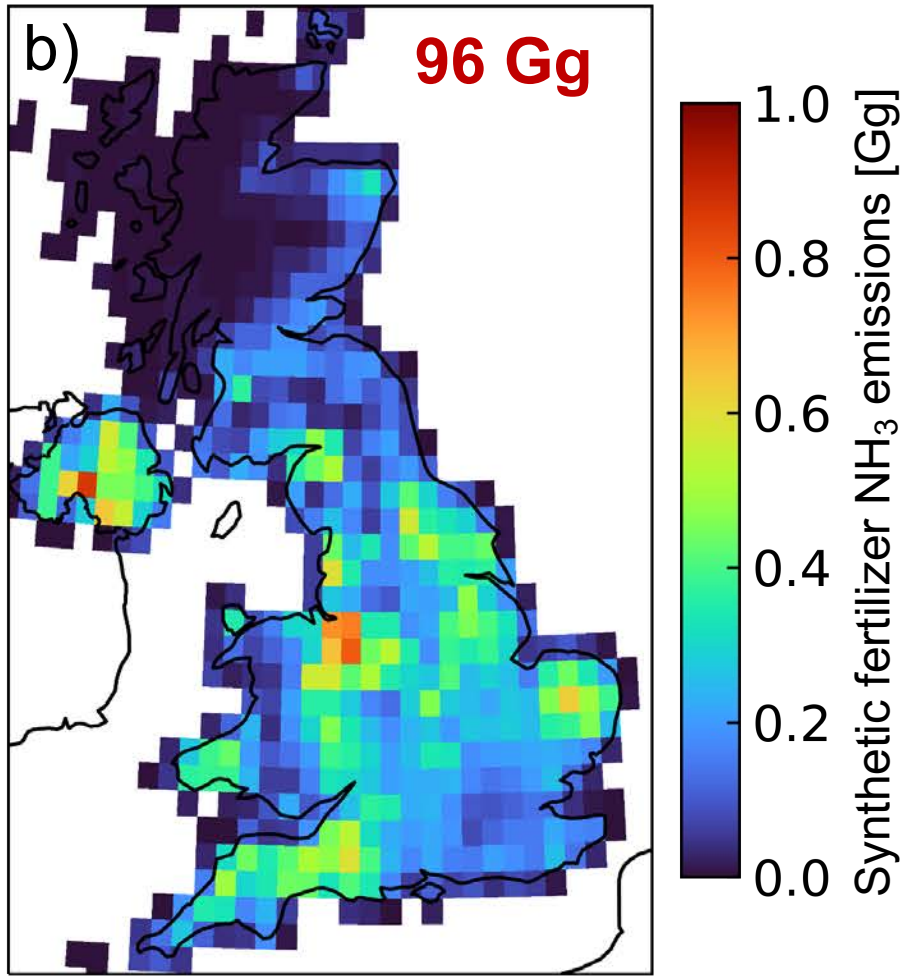


This end-use activity missing in global health burden assessments!

NH_3 emissions from synthetic nitrogen fertilizer

Challenges: Lumped with livestock, at coarse spatiotemporal resolution and outdated



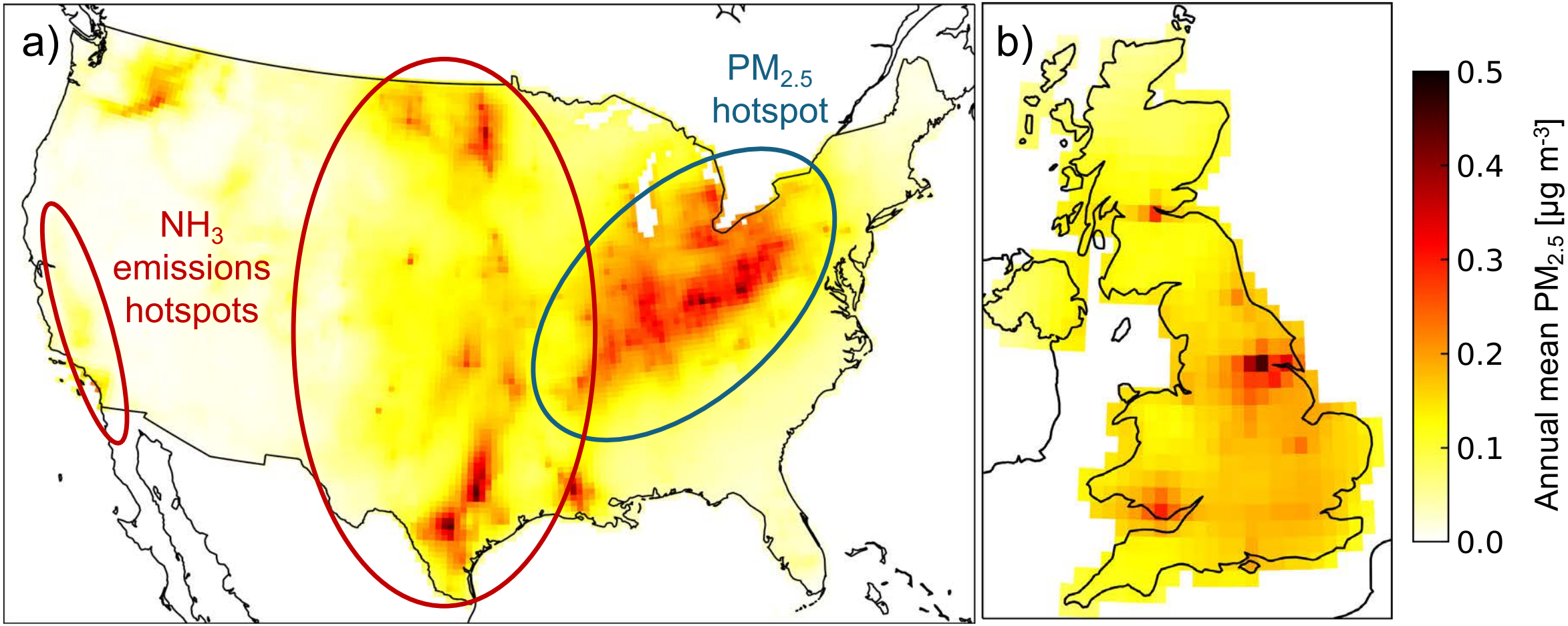


US EPA National Emissions Inventory 2017 species: NH3_Fert
[Data processed by Brian McDonald and Colin Harkins]

Agricultural NH_3 emissions from UK National Atmospheric Emissions Inventory 2019 and fertilizer contribution from Paulot et al. (2014)

$PM_{2.5}$ linked to synthetic nitrogen fertilizer NH_3 emissions

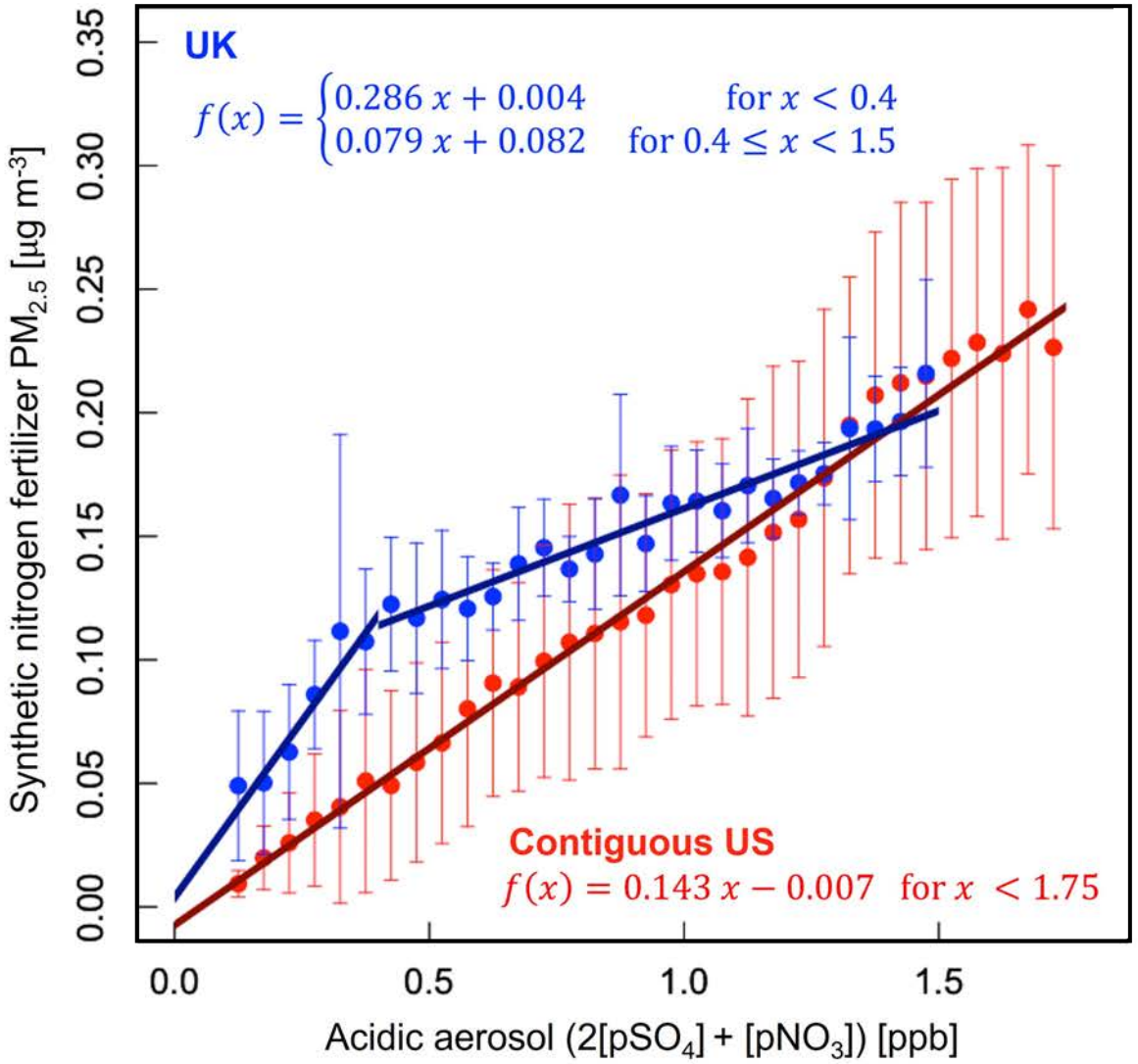
We run GEOS-Chem with and without these NH_3 emissions at 0.25°×0.3125° resolution



A major factor influencing $PM_{2.5}$ formation is acidic aerosol abundance.
Temperature and relative humidity also influence partitioning of semi-volatile NH_3.

Acidic aerosols and synthetic nitrogen fertilizer $PM_{2.5}$

NH_3 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

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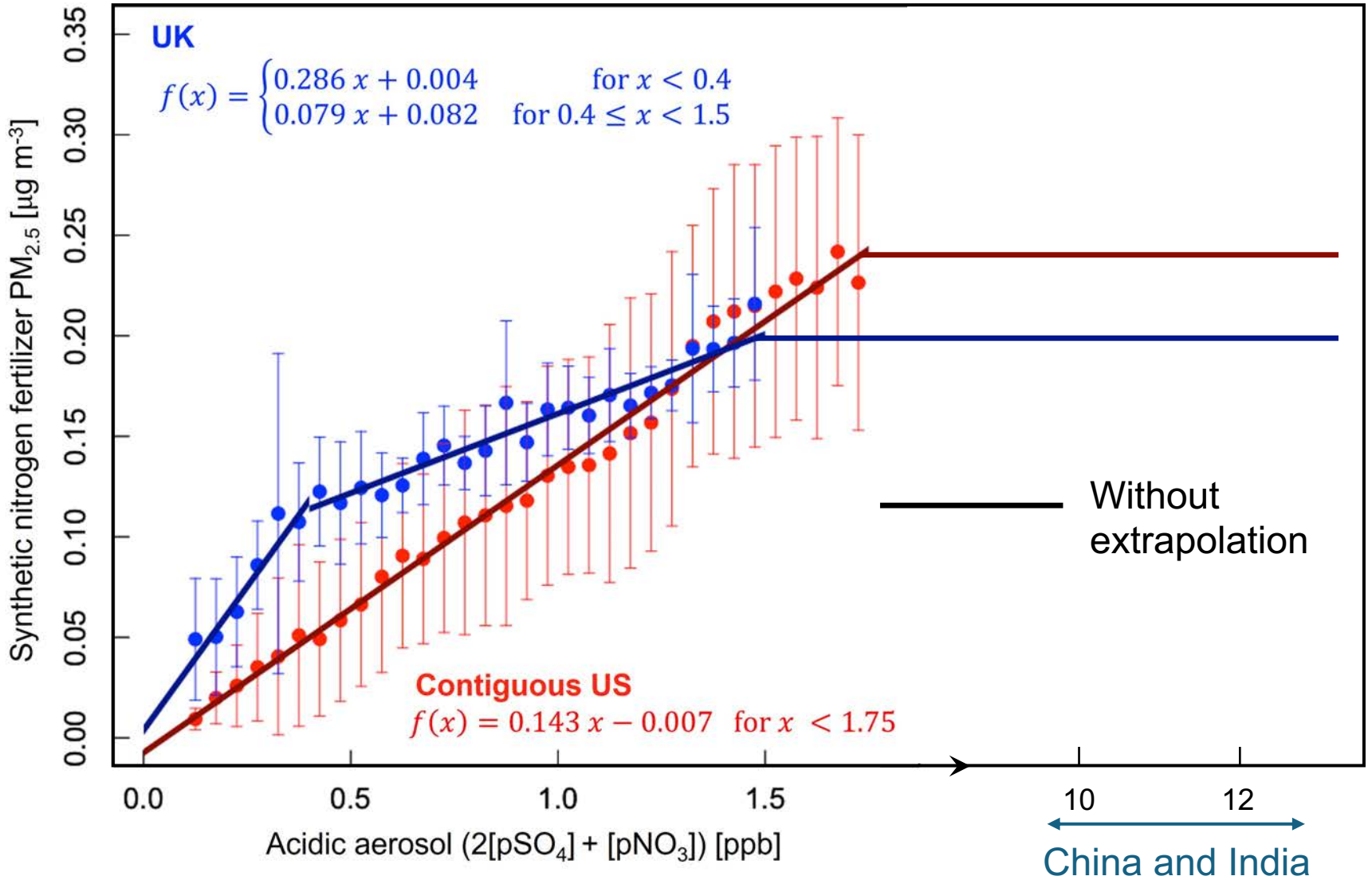

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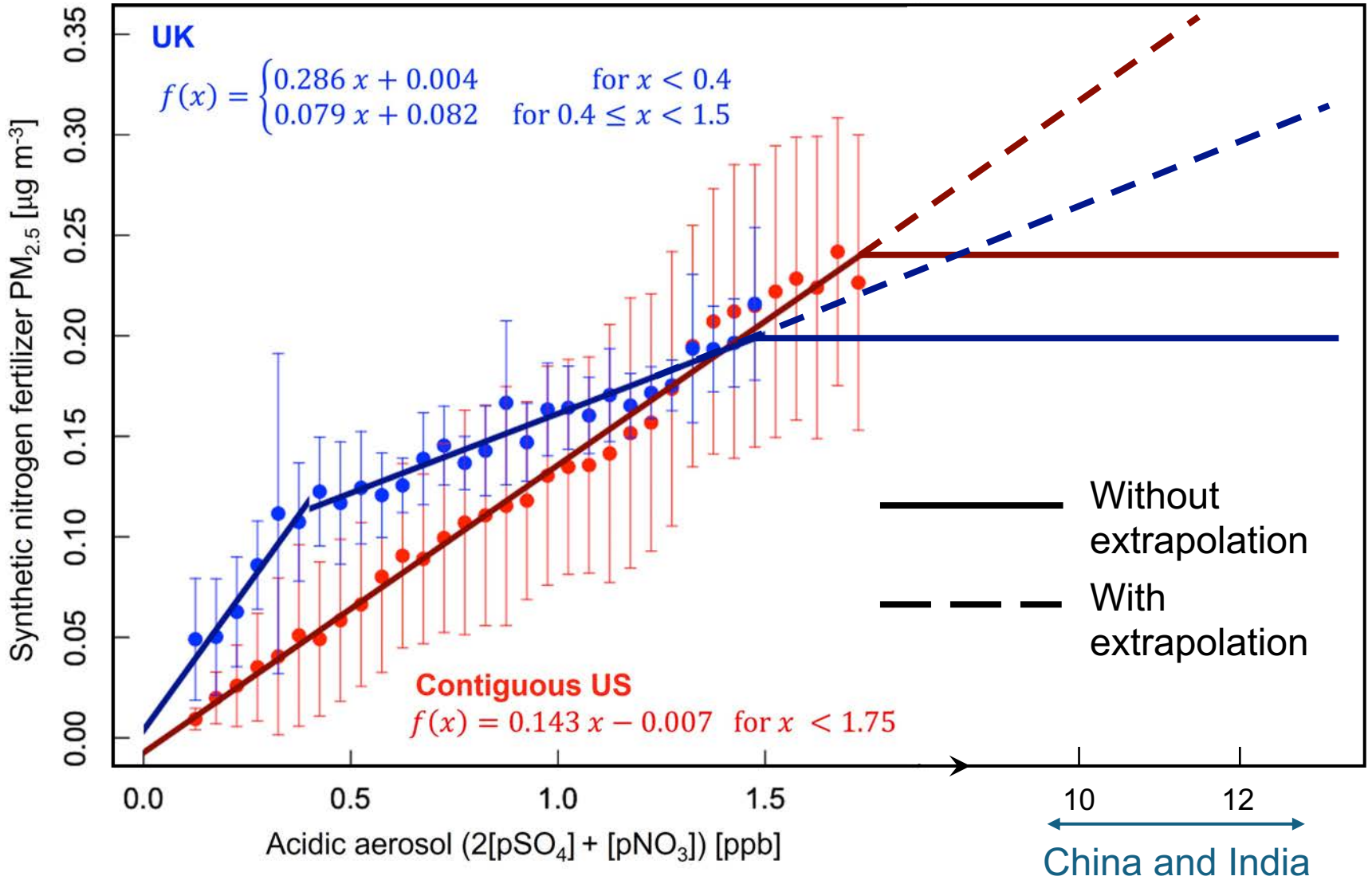

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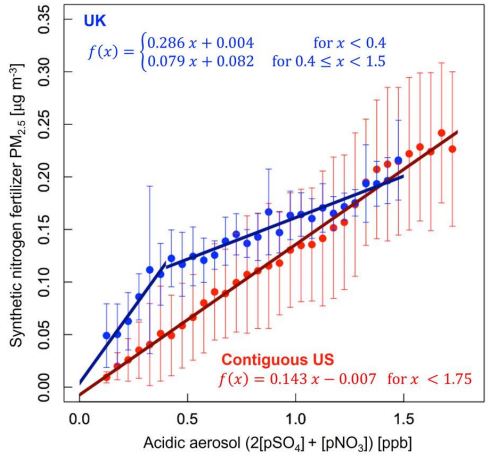
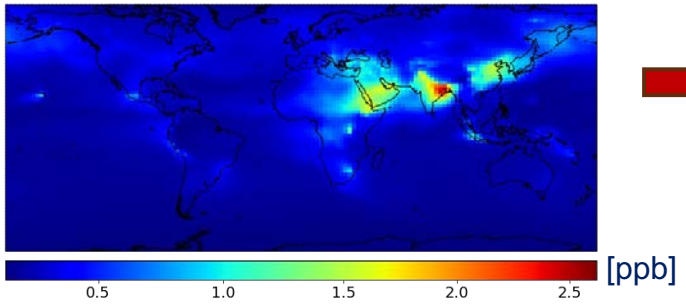
We consider scenarios where the relationship is restricted to maximum acidic aerosol abundance simulated by GEOS-Chem and when sustained beyond this threshold

Estimation of global $PM_{2.5}$ exposure and attributable mortality

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

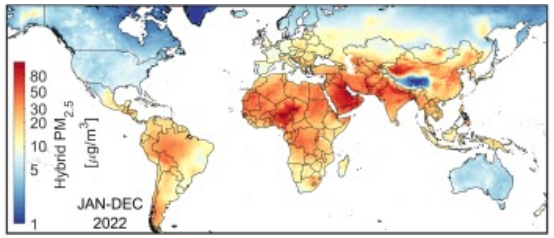


Acidic aerosol abundance from a global 2°×2.5° simulation



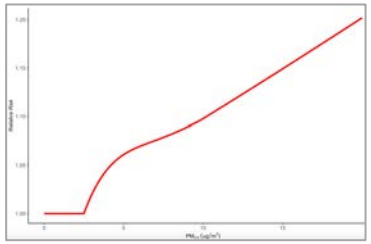
Global $PM_{2.5}$ with and without synthetic nitrogen fertilizer use

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



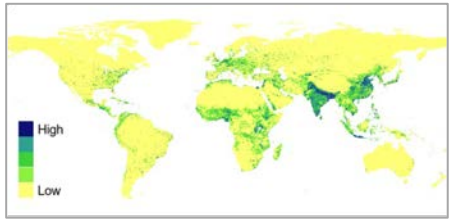
Global synthetic nitrogen fertilizer $PM_{2.5}$

Health impact function [Marais et al., 2023]

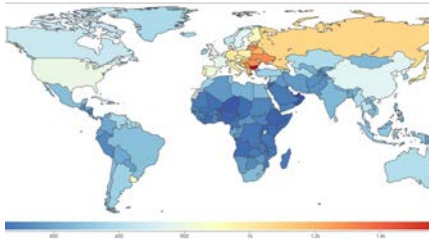


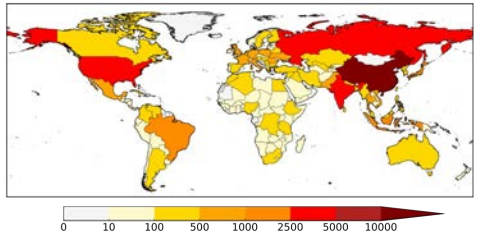
Population attributable fraction

Global population from WorldPop



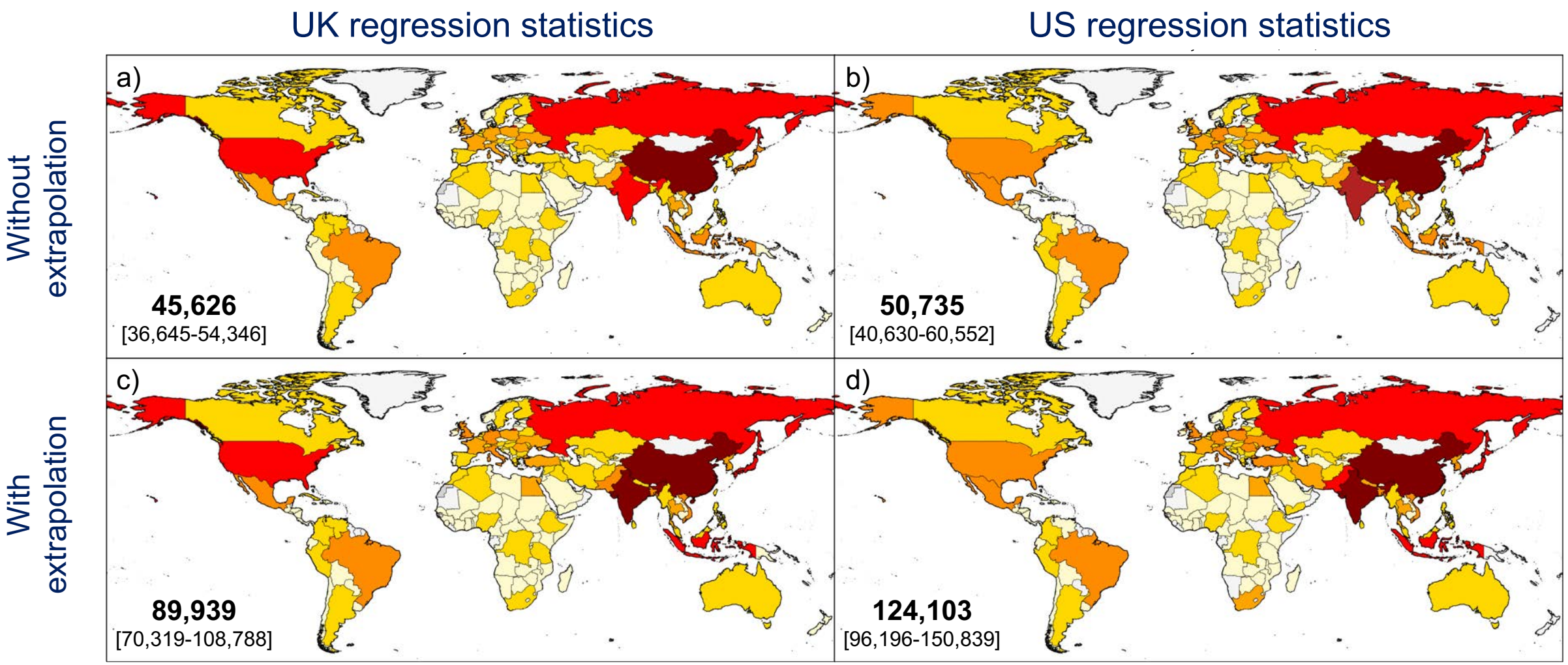
Baseline mortality rates from Global Burden of Disease





Global health burden of synthetic nitrogen fertilizer $PM_{2.5}$

Global health burden of synthetic nitrogen fertilizer use



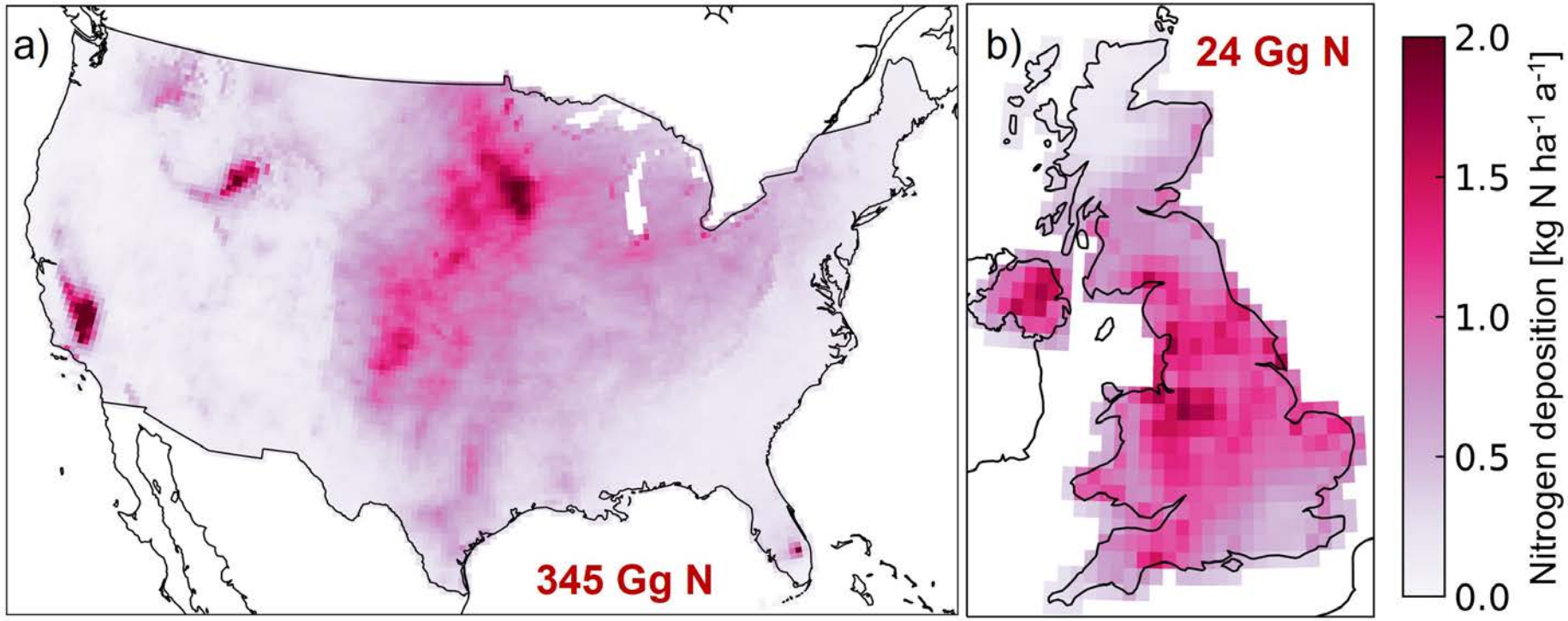
China & India account for 35-60% of total

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

Key takeaways

- **45,000-124,000** global premature deaths linked to fossil fuel derived synthetic nitrogen fertilizer $PM_{2.5}$
- 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)