Global premature mortality due to exposure to air pollution from fossil fuels

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Vohra et al.: https://www.sciencedirect.com/science/article/pii/S0013935121000487
Research Group website: https://maraisresearchgroup.co.uk/

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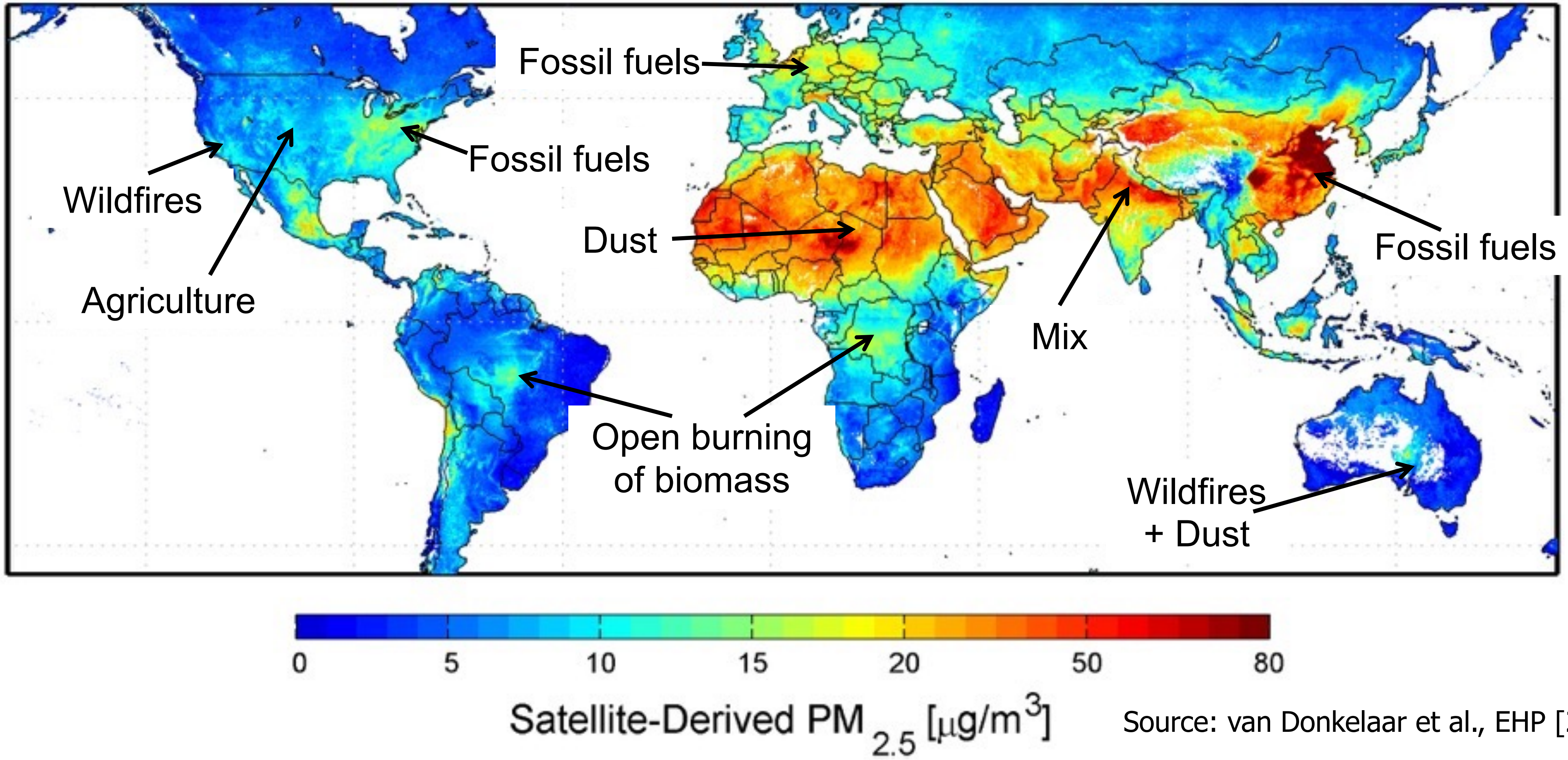
Global distribution of fine particles ($PM_{2.5}$)

$PM_{2.5}$ derived with satellite observations and a model



Source: van Donkelaar et al., EHP [2010]

Dominant sources can be natural or anthropogenic and vary spatially and seasonally

$PM_{2.5}$ from burning fossil fuels

$PM_{2.5}$ precursors emitted from a range of activities that combust fossil fuels

Combustion for transport, industry, energy generation, and domestic heating, lighting and cooking

$PM_{2.5}$ is a mix of primary and secondary components

Direct emission of $PM_{2.5}$
(primary $PM_{2.5}$)

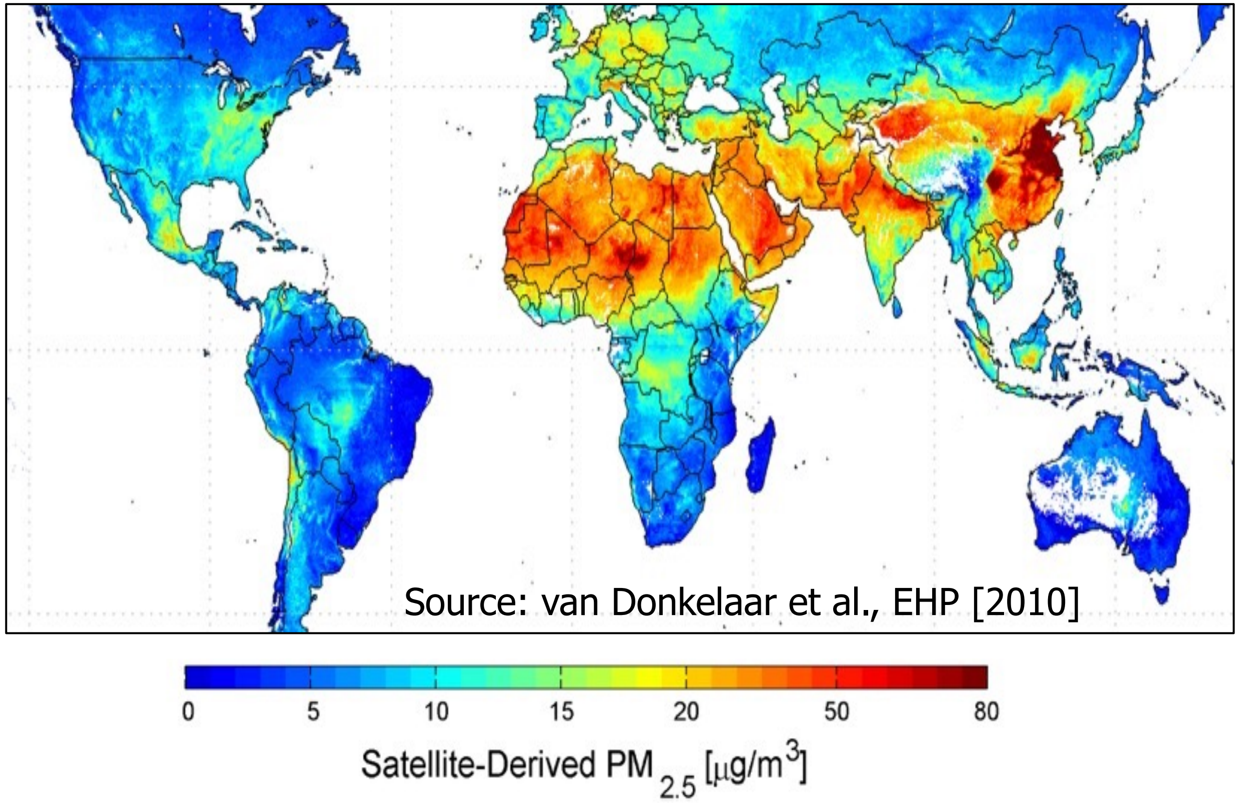
Emission of gas-phase precursors
(secondary $PM_{2.5}$)

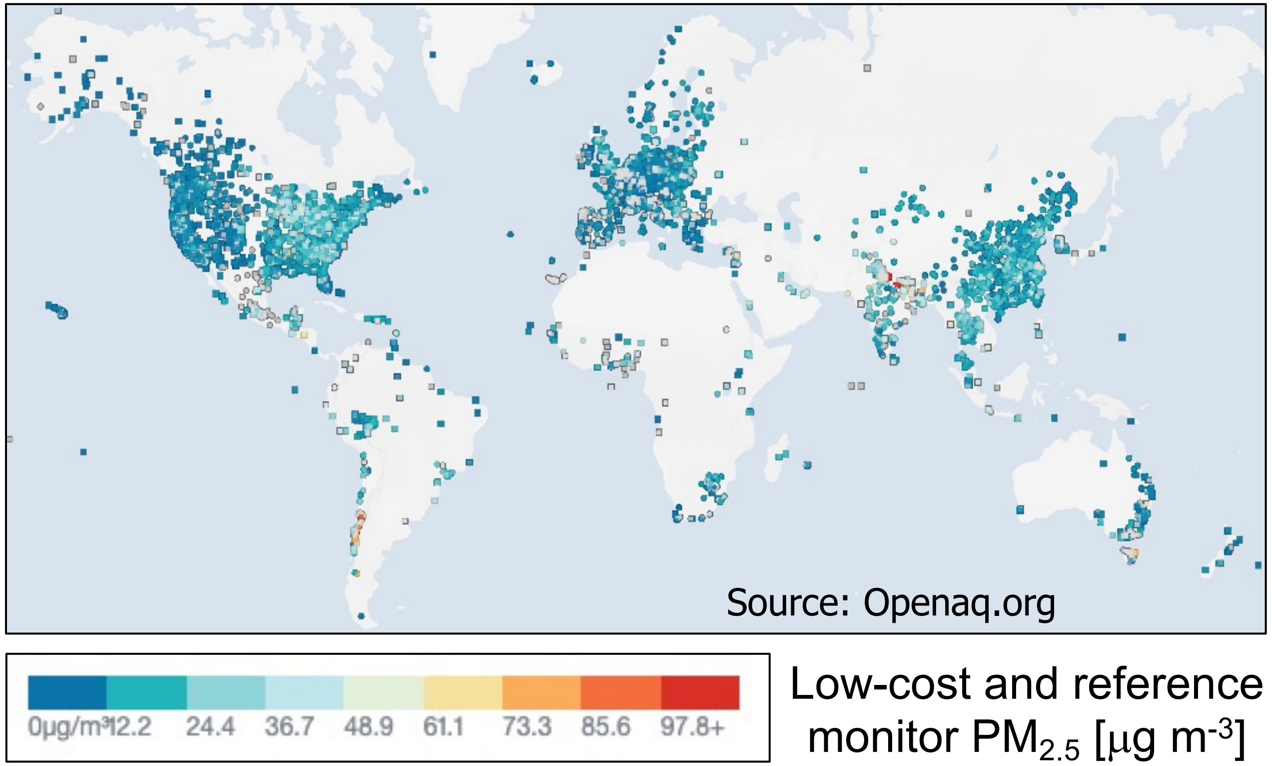
Black carbon — primary
Sulfate, **Nitrate**, **Ammonium** — secondary
Other inorganics
Organic aerosols — primary+secondary

$PM_{2.5}$ includes a mix of components

Challenging to isolate fossil-fuel $PM_{2.5}$ using observations

Satellite products (left) and surface measurements (right) provide total $PM_{2.5}$





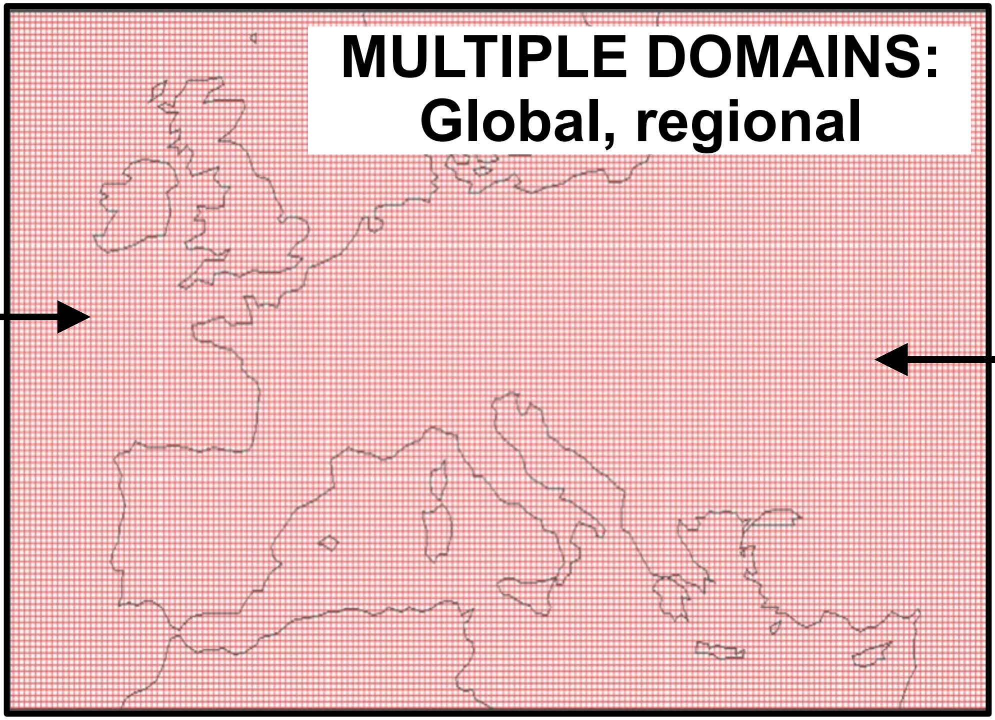
Low-cost and reference monitor $PM_{2.5}$ [μg m^{-3}]

Even with measurements of the individual $PM_{2.5}$ components, it is challenging to tease out the contribution from fossil fuels, **so we use a model**.

Simulate surface $PM_{2.5}$ using the GEOS-Chem model

Comprehensive emissions sources

3D Atmospheric Chemistry Transport Model



Chemistry, transport loss, processes

NASA Meteorology

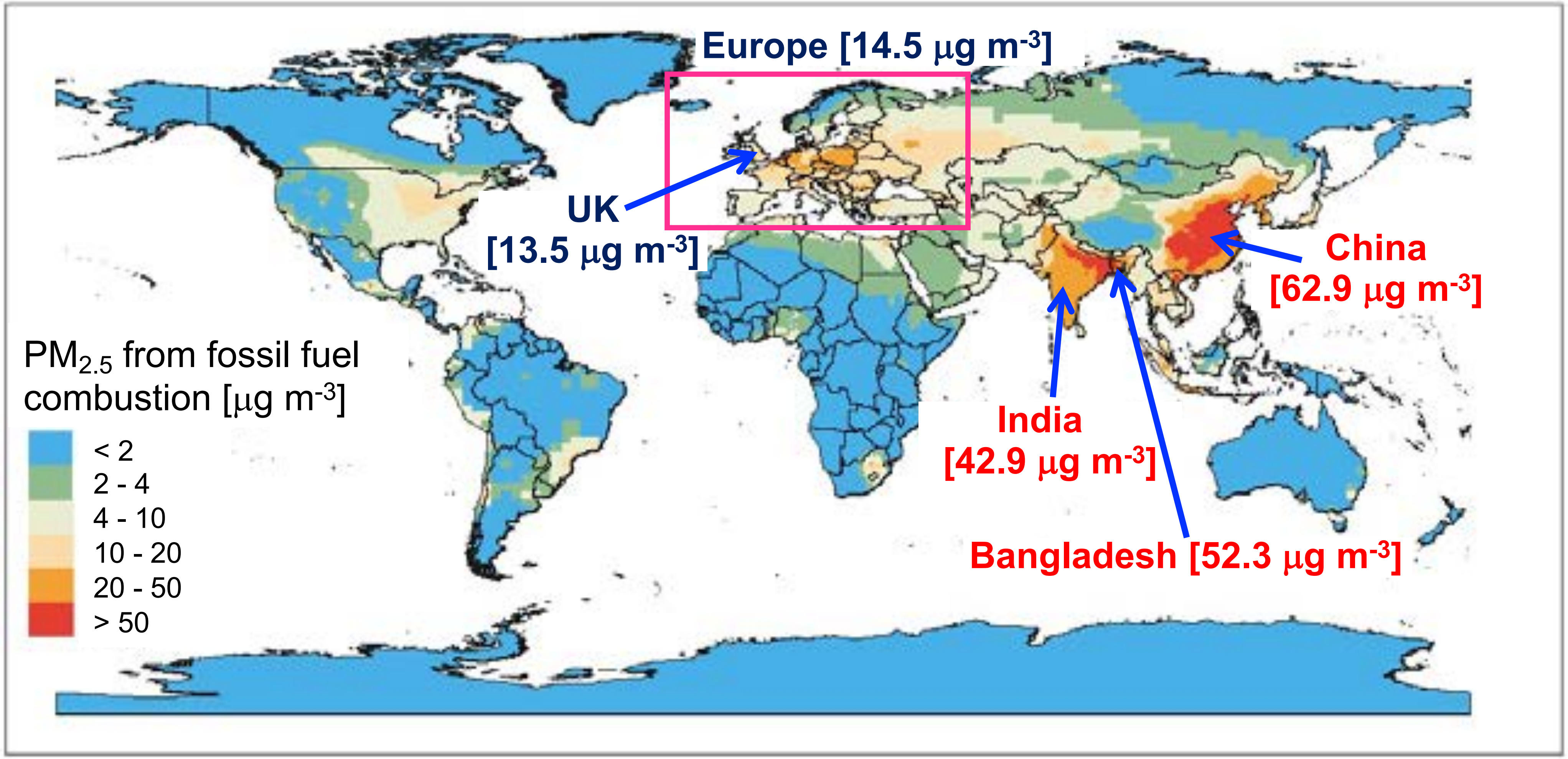
$PM_{2.5}$ from non-fossil-fuel sources

GEOS-Chem manual: http://acmg.seas.harvard.edu/geos/

GEOS-Chem

Model estimate of fossil fuel $PM_{2.5}$

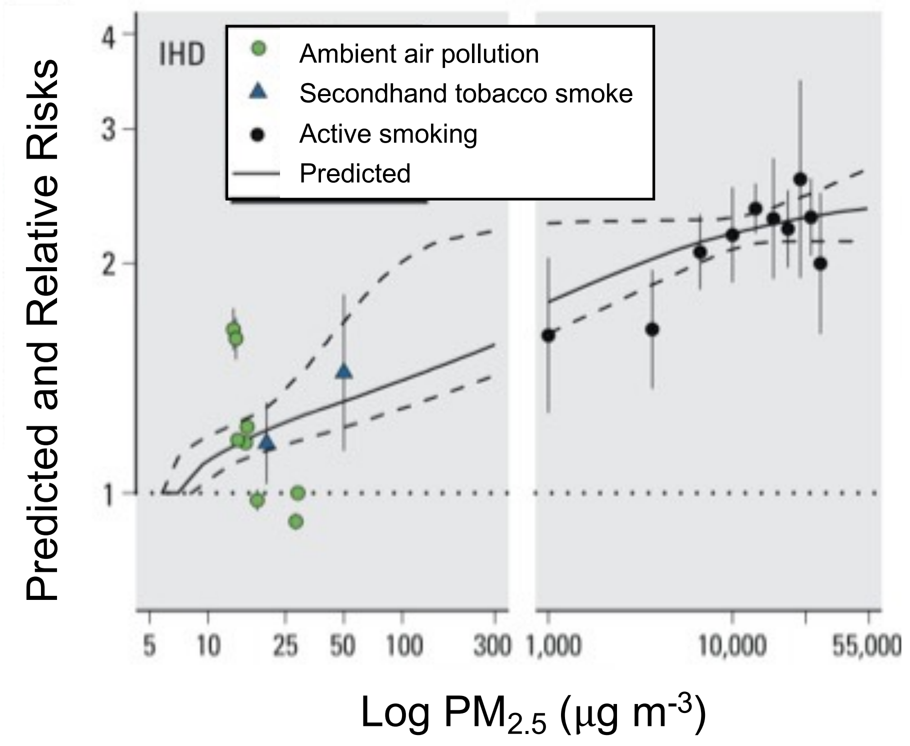
Difference between model simulations with and without fossil fuel $PM_{2.5}$



Hotspots are in China, Bangladesh, India, and central Europe

Standard and widely used risk assessment models

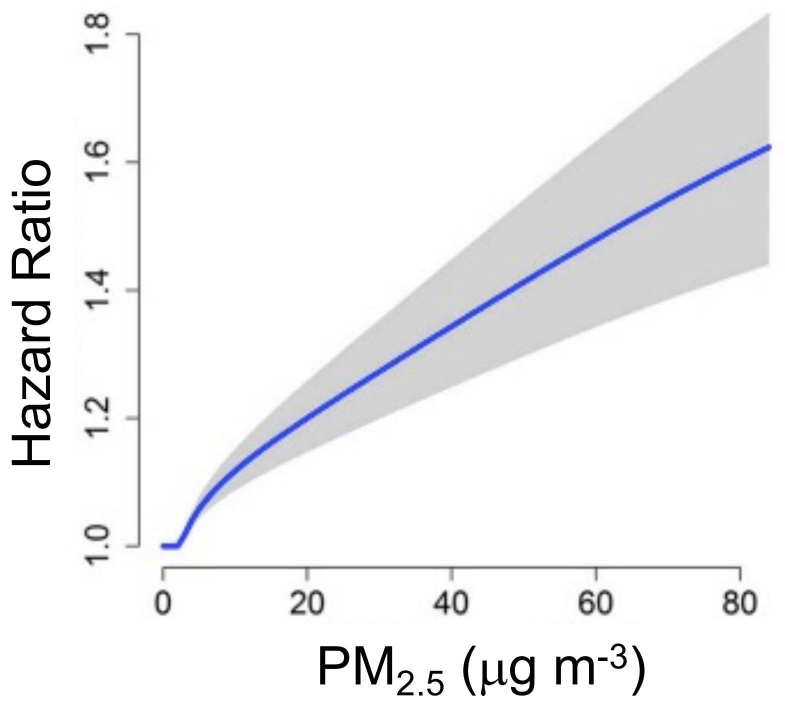
Integrated Exposure-Response (IER)



[Burnett et al., 2014]

Data includes active and passive smoking to address outdoor $PM_{2.5}$ > 40 $\mu g\ m^{-3}$

Global Exposure Mortality Model (GEMM)

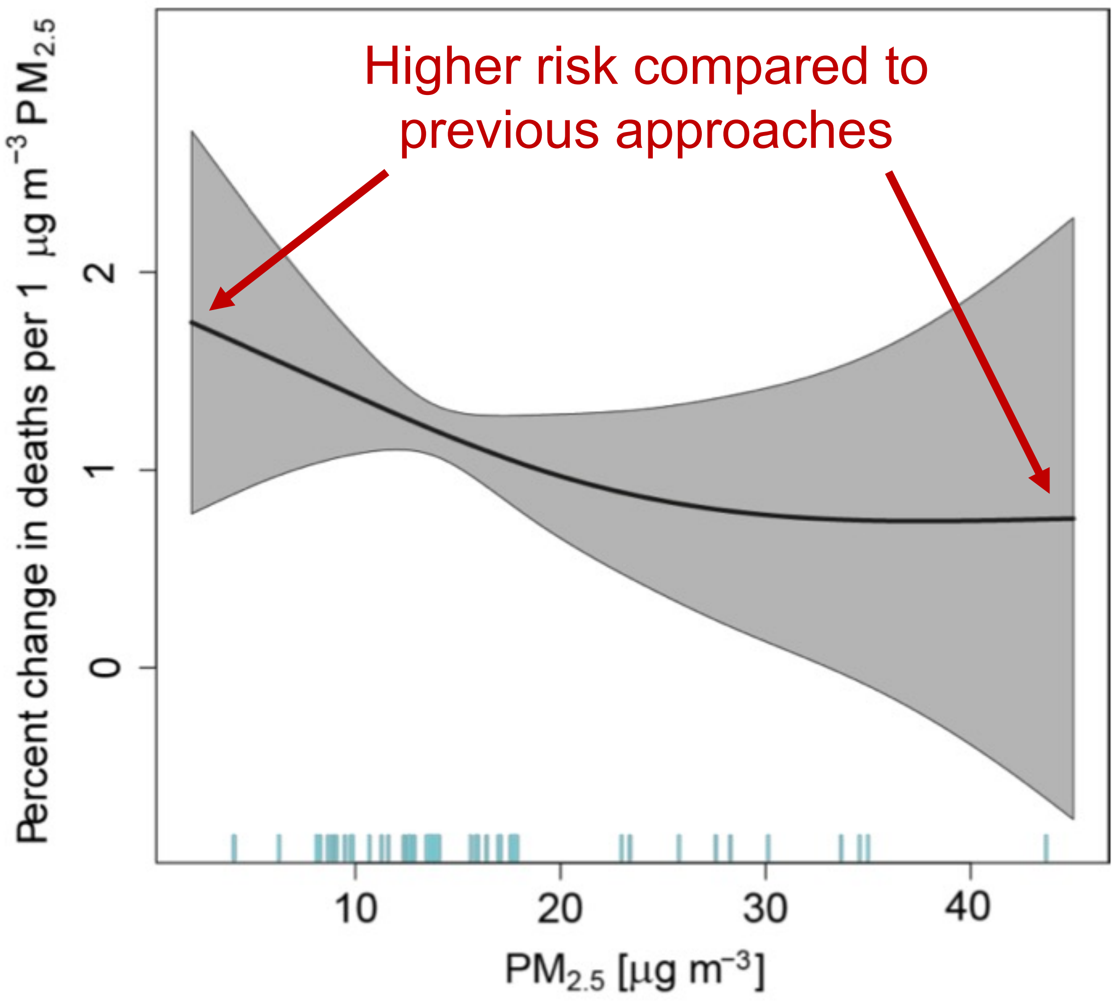


[Burnett et al., 2018]

41 cohort studies and model constrained using 4 parameters

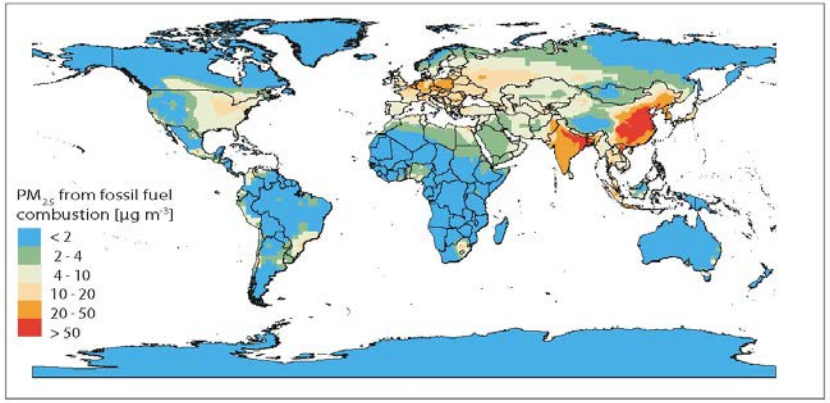
Updated risk assessment model used in our study

- Flexible shape of concentration-response function
- More cohort studies, and wider concentration and age range than previous approaches
- Includes death from all-causes

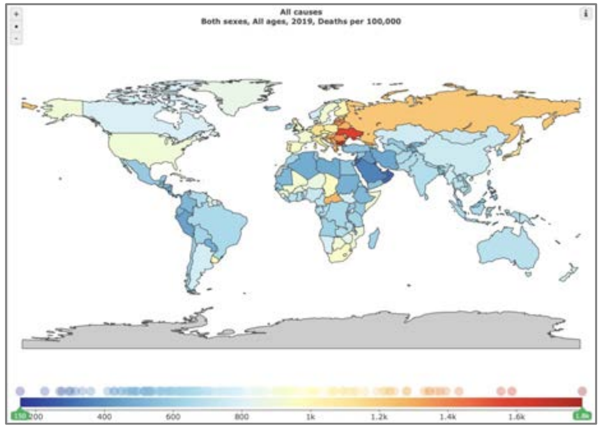


[Vodonos et al., 2018]

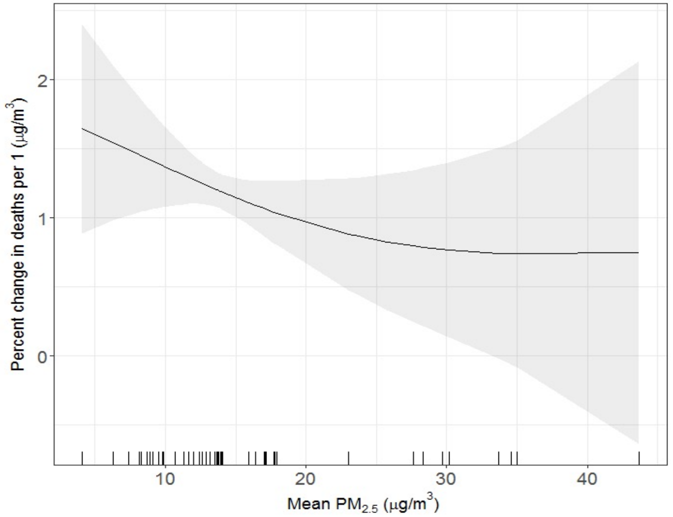
Methodology for health impact calculation



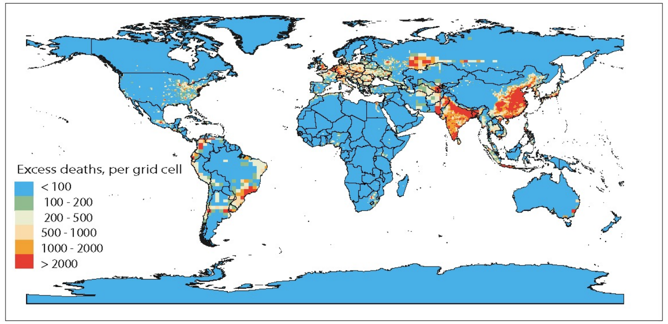
Fossil-fuel PM$_{2.5}$ from GEOS-Chem



Baseline mortality from Global Burden of Disease



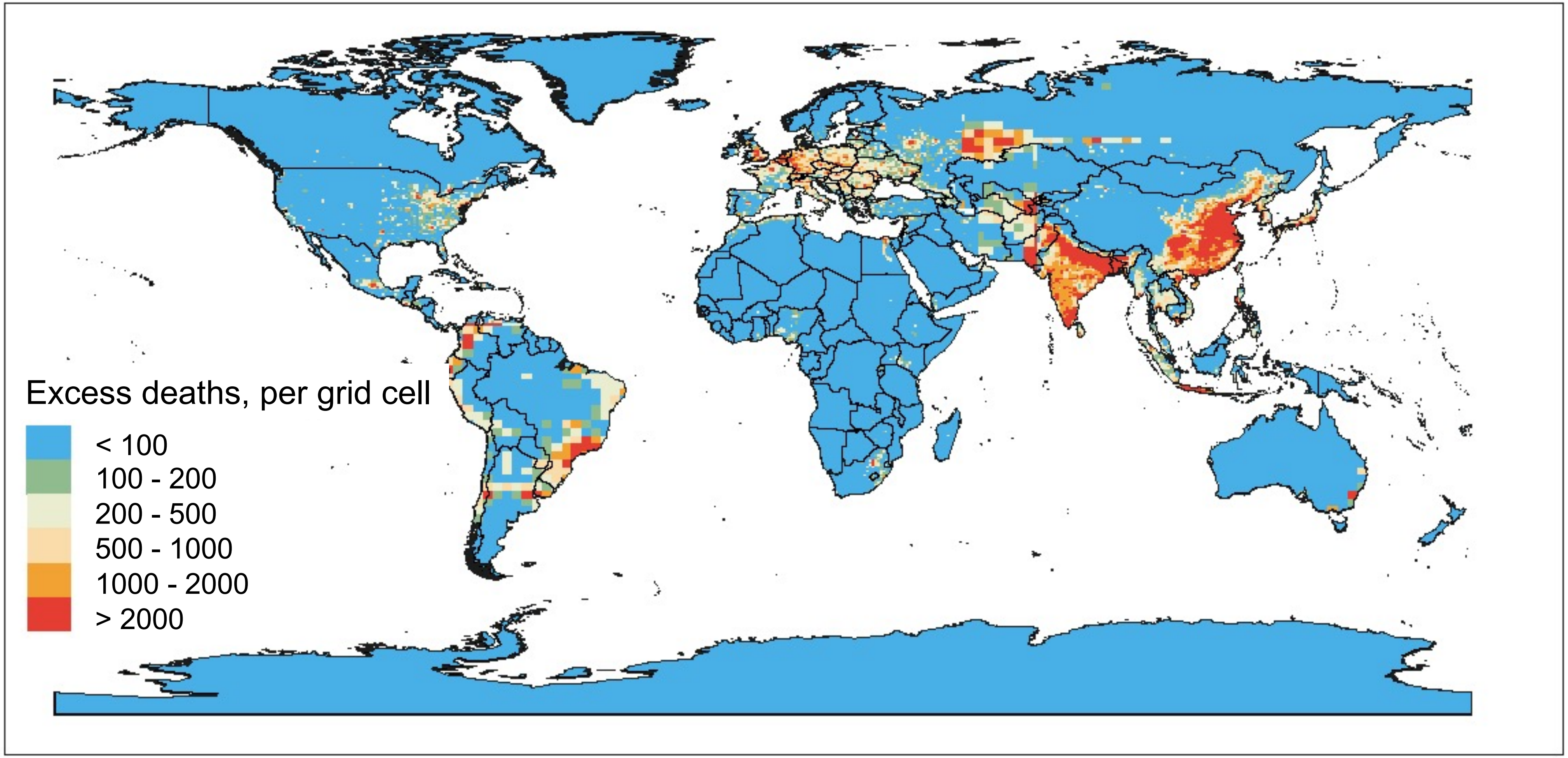
Meta-analysis concentration-response function from cohort studies



Global premature mortality estimates

We use the derived fossil-fuel PM$_{2.5}$ with baseline mortality in the meta-analysis concentration-response function to estimate global premature mortality

Estimated global premature mortality from fossil fuel combustion

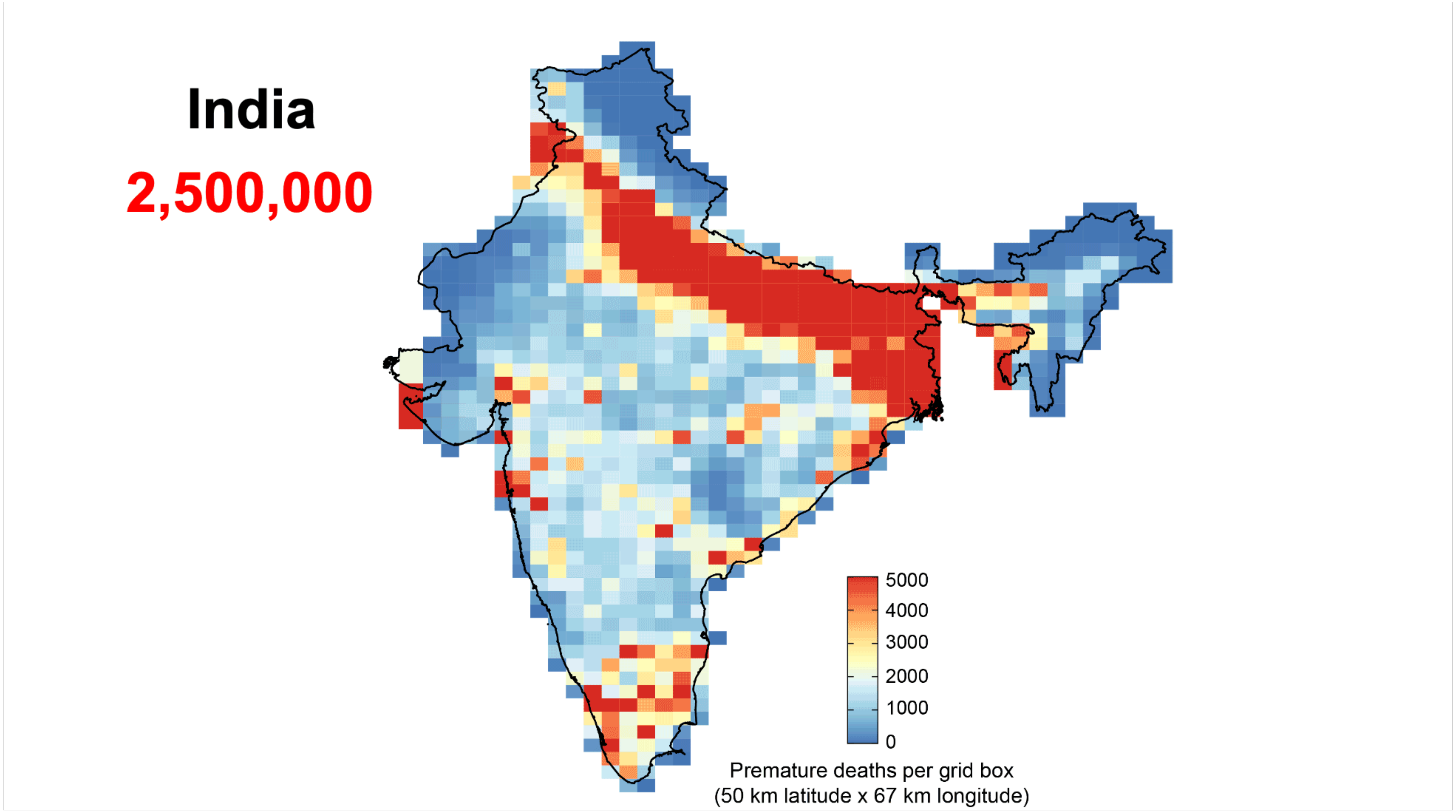


10.2 million premature deaths attributed to fossil-fuel $PM_{2.5}$ in 2012

[-47 million, 17 million]

[Vohra et al., 2021]

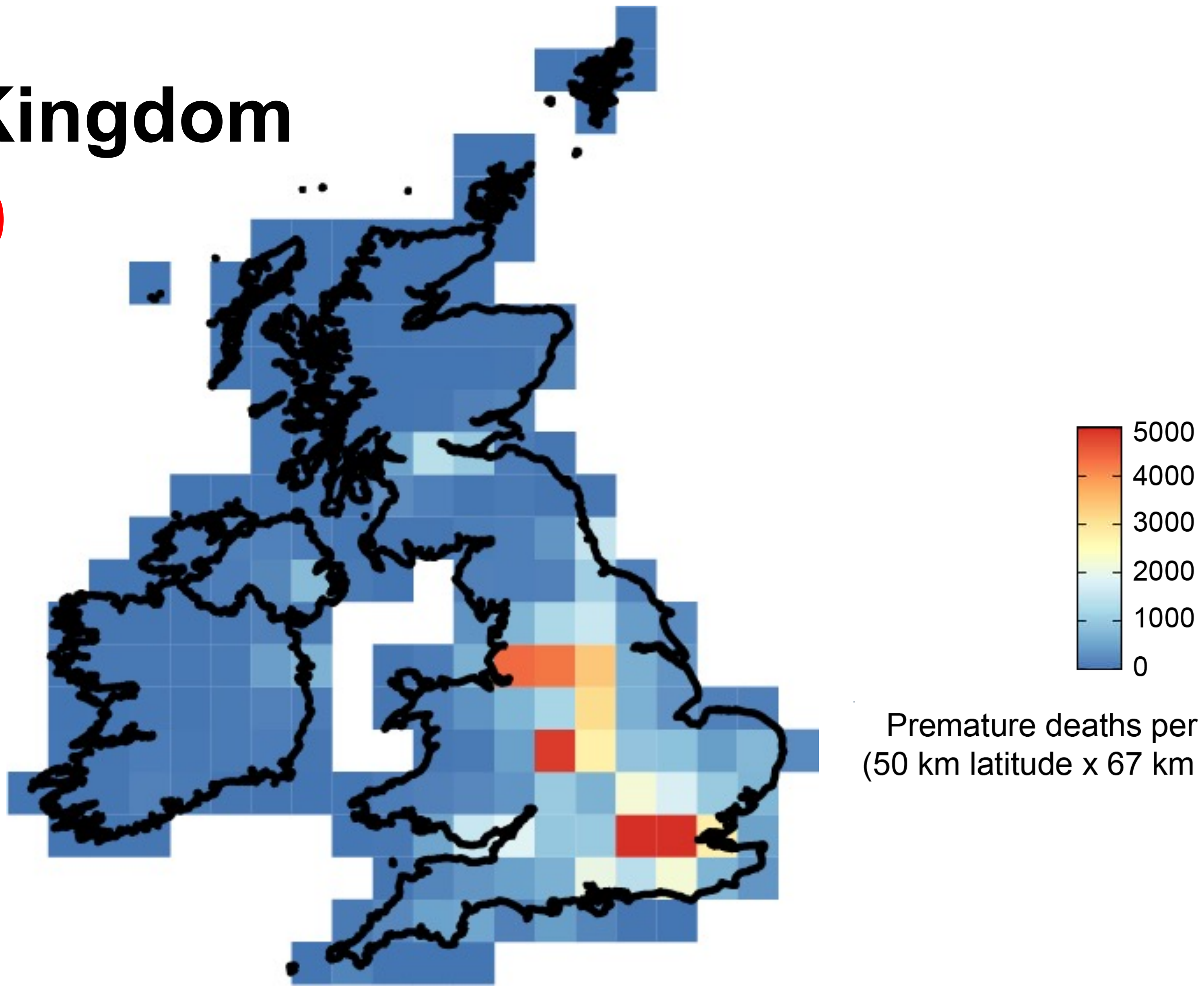
Regional premature mortality from fossil fuel combustion



Regional premature mortality from fossil fuel combustion

United Kingdom

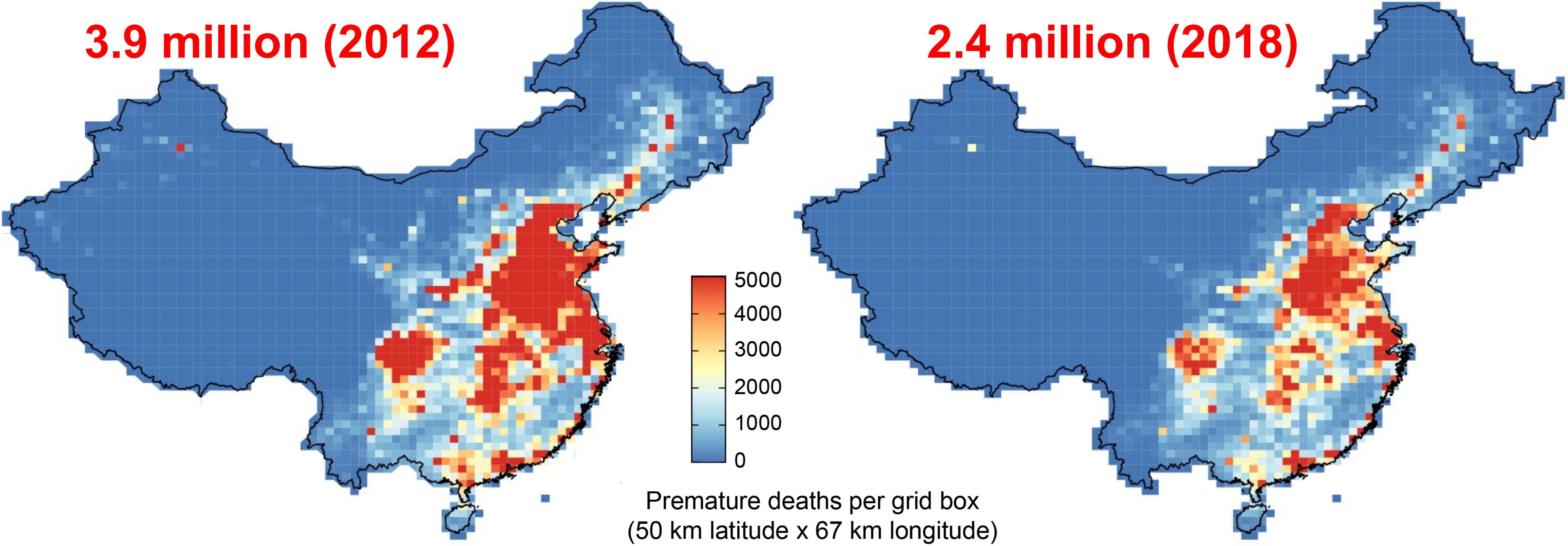
99,000



Premature deaths per grid box
(50 km latitude x 67 km longitude)

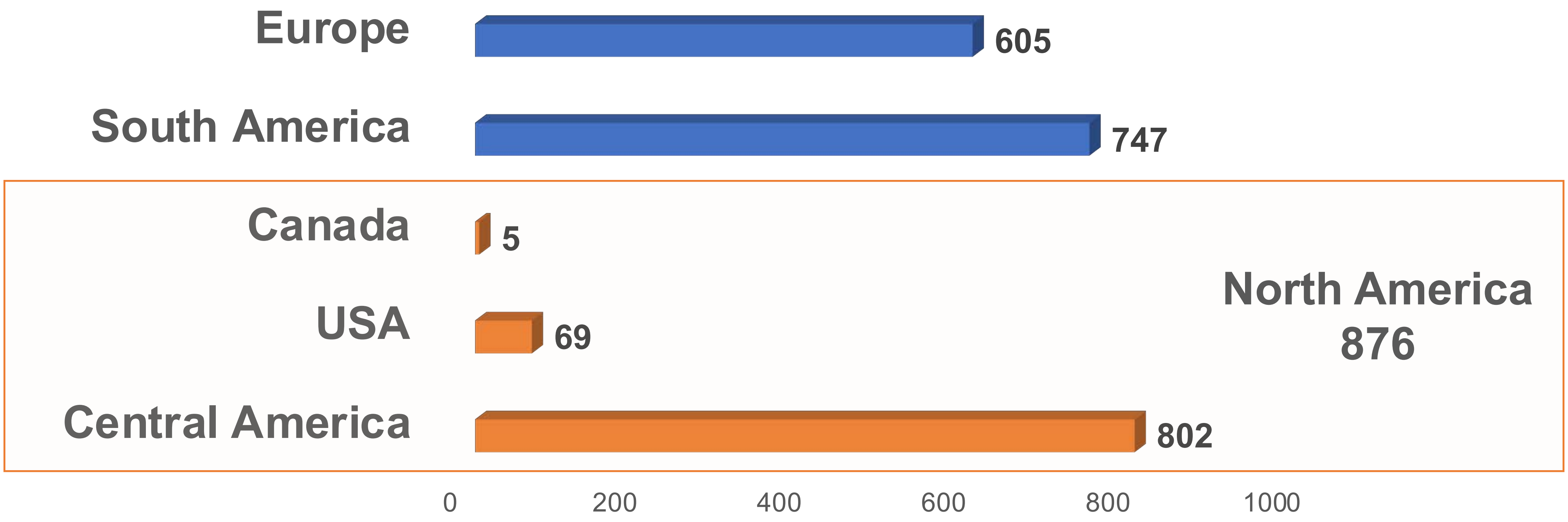
Policies can help mitigate these premature deaths

China



Dramatic reduction in $PM_{2.5}$ in China from 2012 to 2018 decreases premature deaths by 1.5 million

Children are also affected by air pollution from fossil fuels



More than 2000 premature deaths from lower respiratory infection alone for children < 5 years old

Implications of and response to our findings

We calculate global premature mortality that is much greater than previous estimates (updated risk assessment model, higher spatial resolution $PM_{2.5}$)

Swell of media attention from leading news agencies and advocacy groups

https://www.theguardian.com/environment/2021/feb/09/fossil-fuels-pollution-deaths-research

Translated into **many languages** for audiences in France, Spain, India, Canada, China, Central and South America

Heightened immediate urgency to transition to cleaner and more sustainable energy sources