Fossil-fuel related $PM_{2.5}$ pollution global mortality estimates using GEOS-Chem

Karn Vohra (kxv745@bham.ac.uk), Alina Vodonos, Joel Schwartz, Eloise A. Marais, Melissa P. Sulprizio, Loretta J. Mickley

AASC 2020 5 November 2020

UNIVERSITY OF BIRMINGHAM

WALLACE GLOBAL FUND

Why fossil-fuel related $PM_{2.5}$?

4.2 million deaths attributed to ambient $PM_{2.5}$ in 2015

[Cohen et al. 2017]

Dominant anthropogenic source;
Can be easily controlled

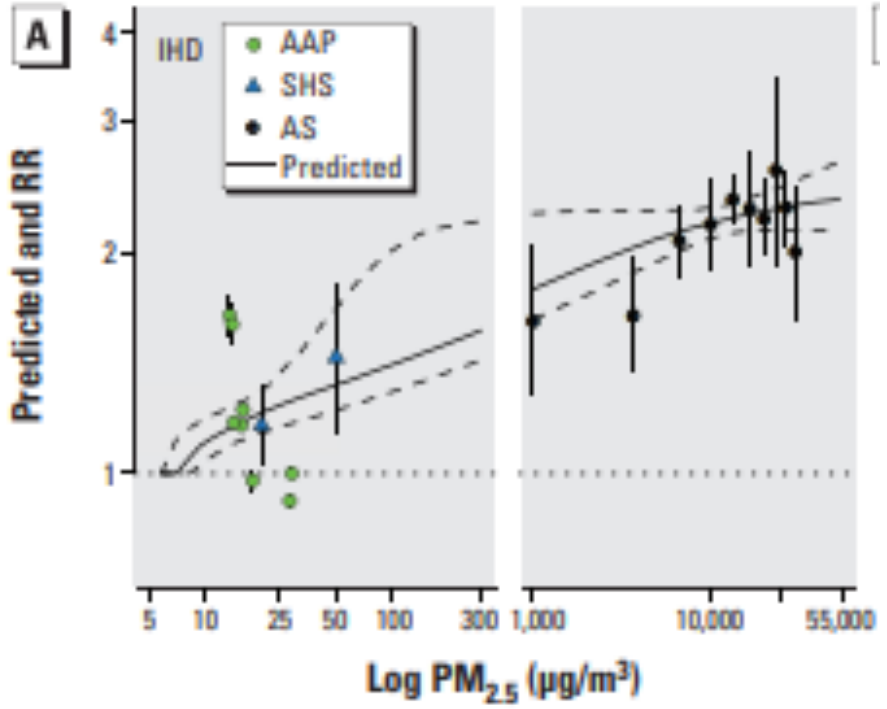
Particulate matter ($PM_{2.5}$)

- Fossil-fuels
- Dust ✖
- Wildfire smoke ✖
- Others ✖

In this study, we use a chemical transport model GEOS-Chem to estimate $PM_{2.5}$ contribution from fossil-fuel combustion

Previous health impact models have been useful but have had certain limitations

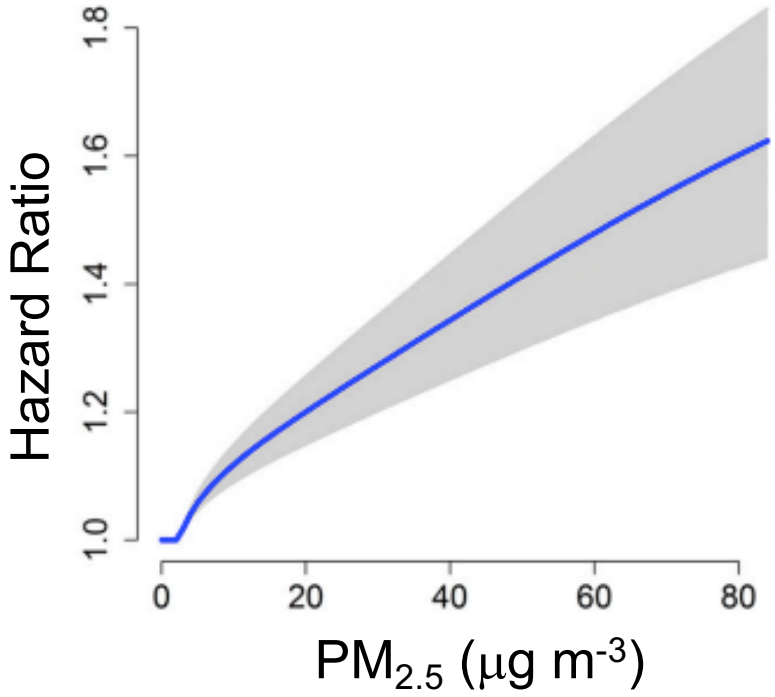
Integrated Exposure-Response (IER)



[Burnett et al., 2014]

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

Global Exposure Mortality Model (GEMM)

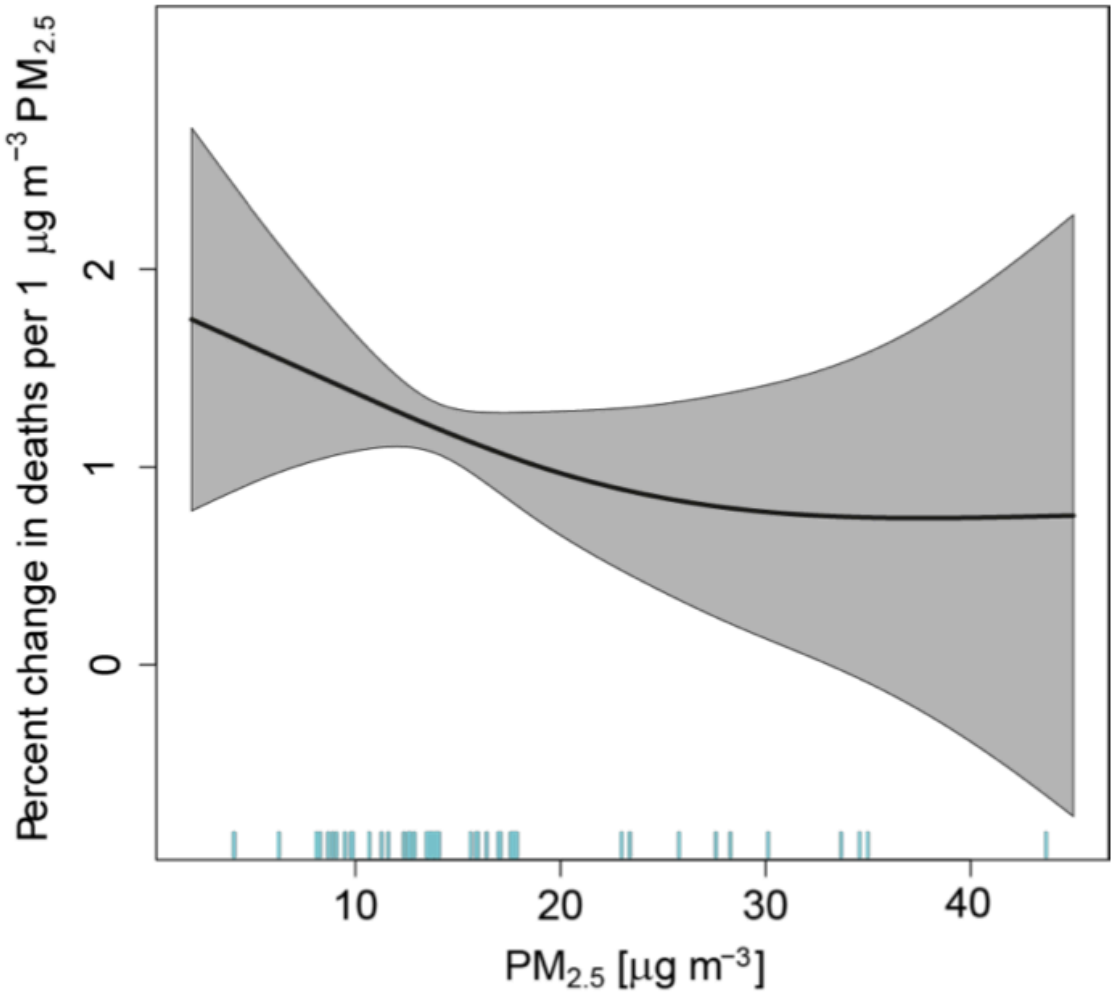


[Burnett et al., 2018]

41 cohort studies and model constrained using 4 parameters

We use concentration-response-function (CRF) from the meta-analysis of 53 studies

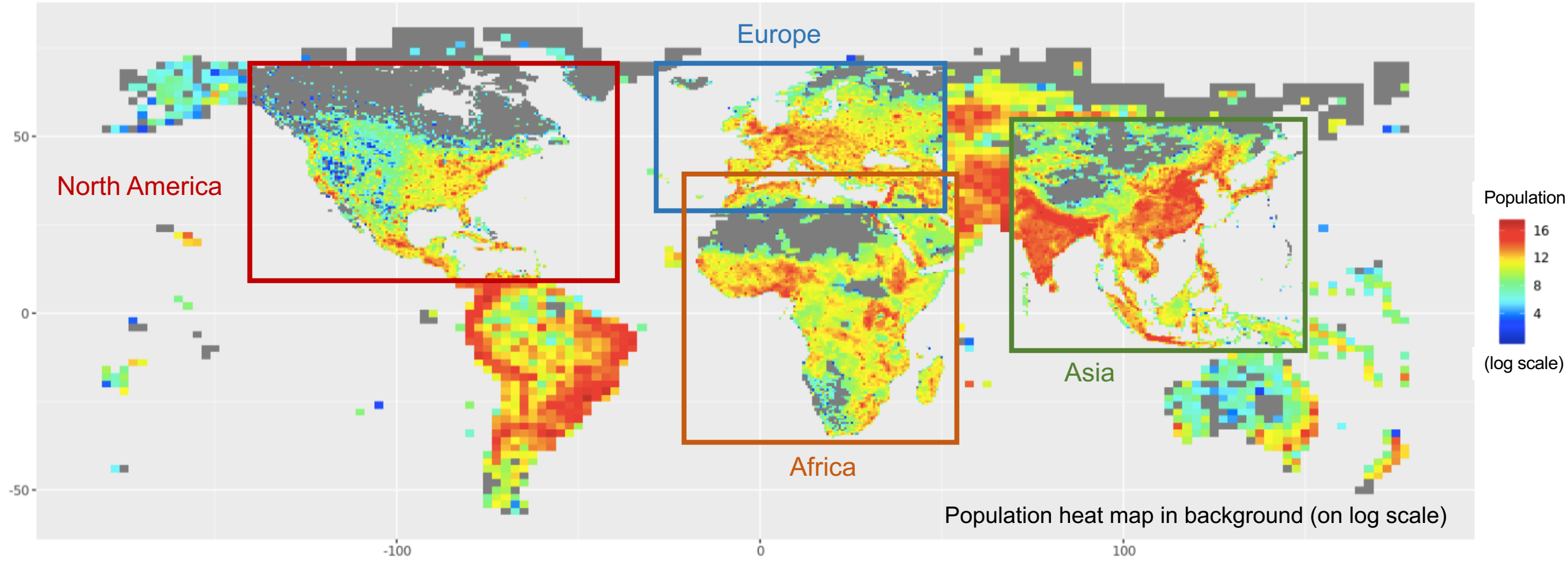
- Flexible shape of CRF
- Incorporates more studies
- Wider concentration and population age range
- Includes death from all-causes



[Vodonos et al., 2018]

We carry both global and regional scale GEOS-Chem simulations replicating 2012 pollution conditions

GEOS-Chem v10-01, driven by 2012 GEOS-5 offline assimilated meteorology



Global (coarse grid resolution : 2° × 2.5°)

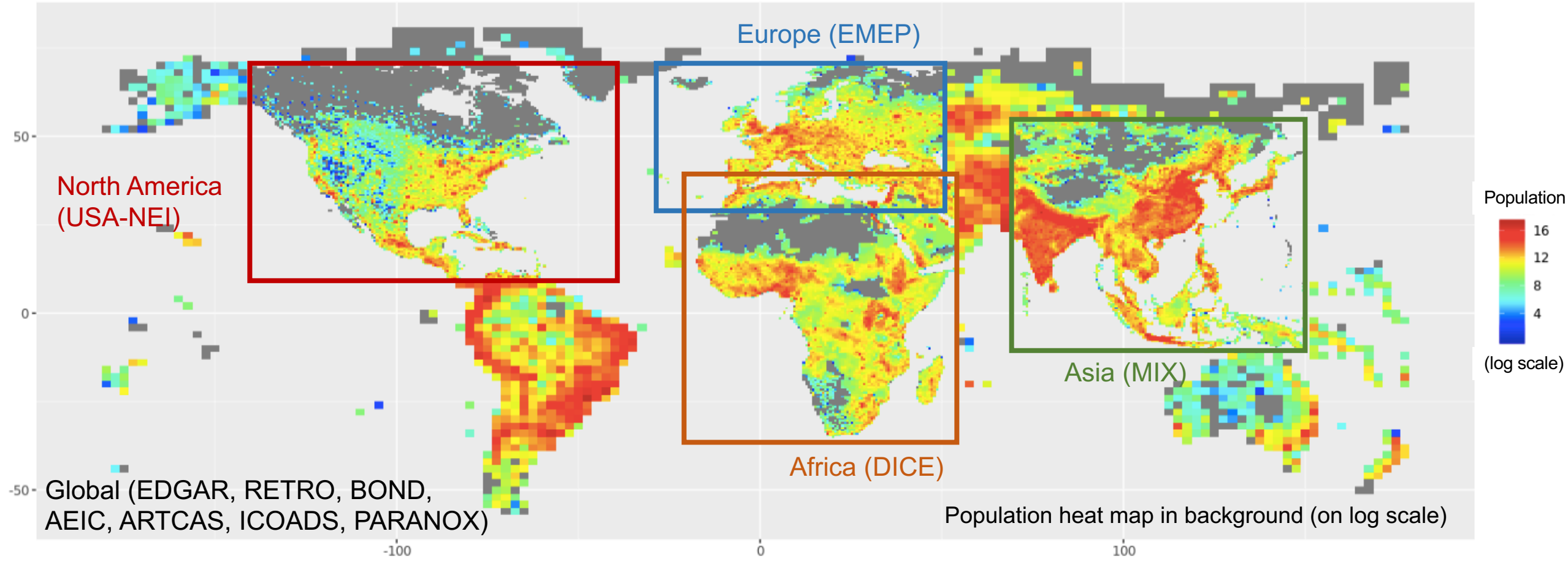
Regional (fine grid resolution : 0.5° × 0.67°)

Simulation 1 : All emissions

Simulation 2 : Fossil-fuel turned OFF

We carry both global and regional scale GEOS-Chem simulations replicating 2012 pollution conditions

GEOS-Chem v10-01, driven by 2012 GEOS-5 offline assimilated meteorology



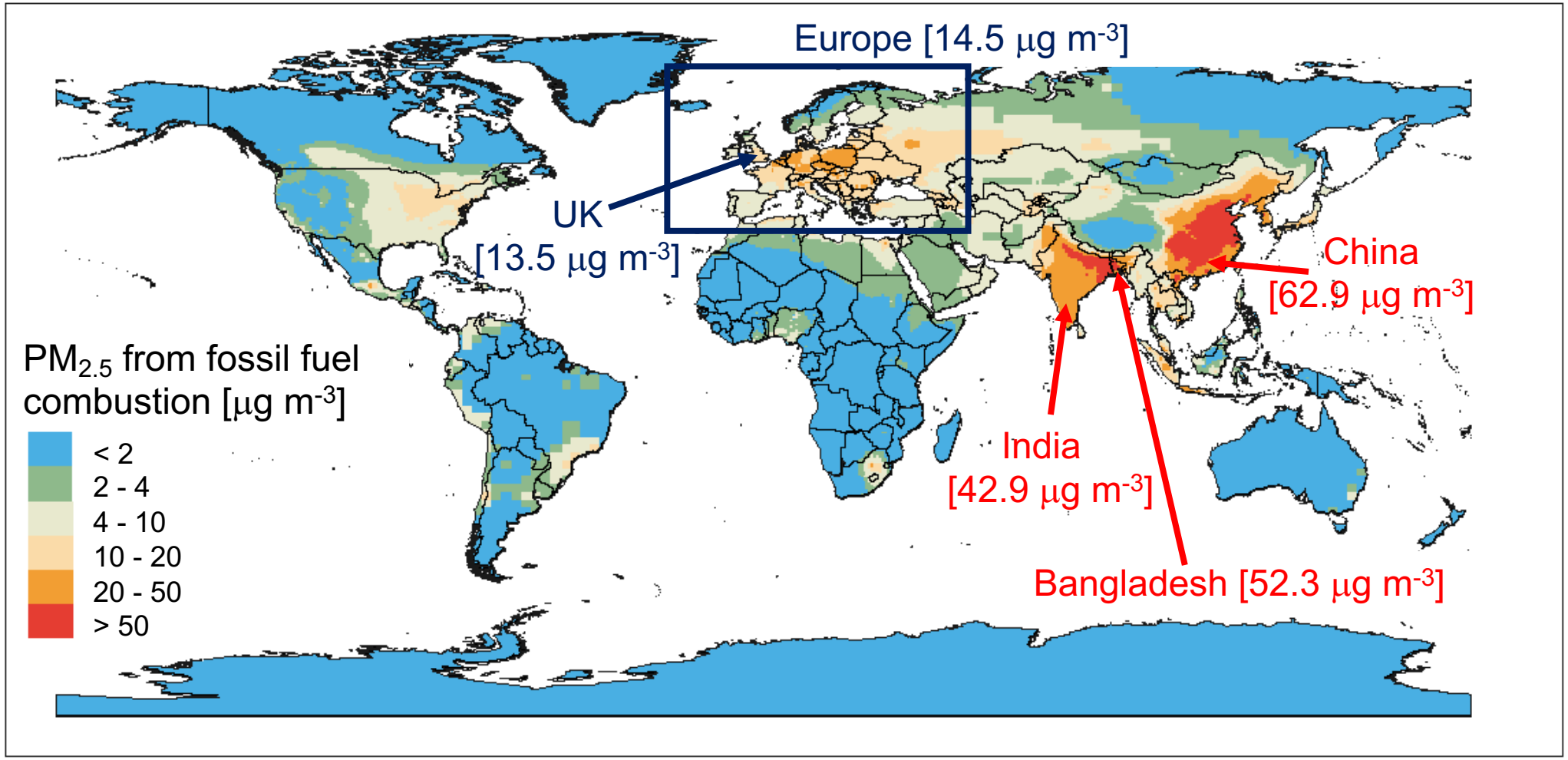
Global (coarse grid resolution : 2° × 2.5°)

Regional (fine grid resolution : 0.5° × 0.67°)

Simulation 1 : All emissions

Simulation 2 : Fossil-fuel turned OFF

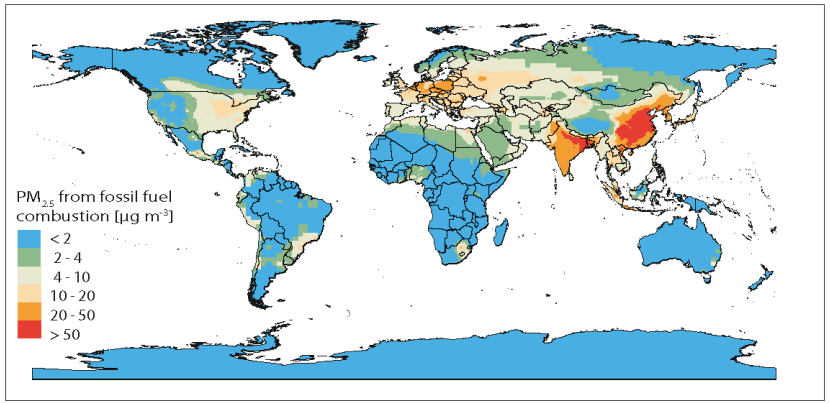
Fossil-fuel estimates from GEOS-Chem simulations



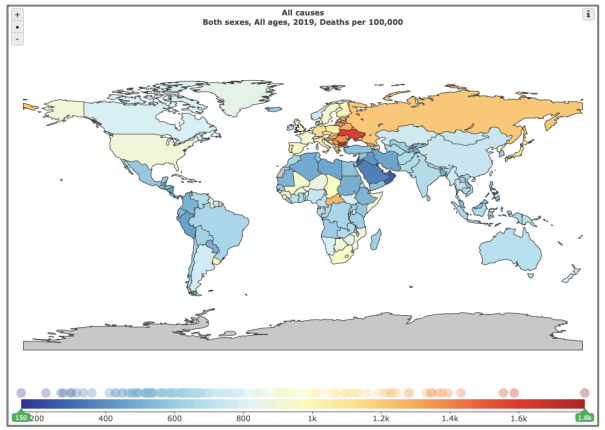
China, Bangladesh and India have the highest annual mean fossil-fuel $PM_{2.5}$ in 2012

[Vohra et al., in review, *Environ. Res.*]

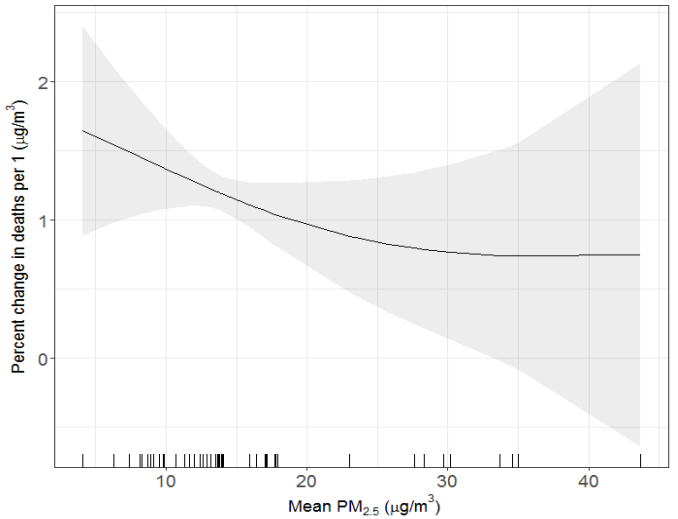
Methodology for health impact calculation



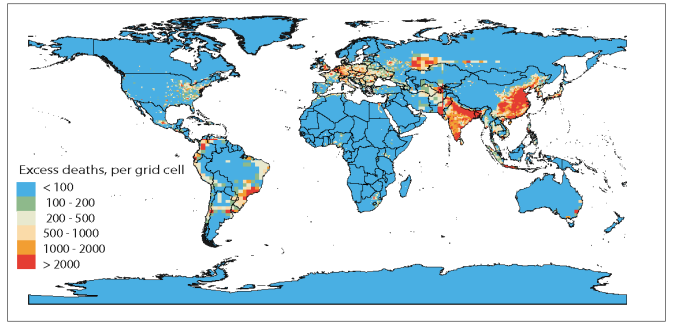
Fossil-fuel $PM_{2.5}$ from GEOS-Chem



Baseline mortality from GBD



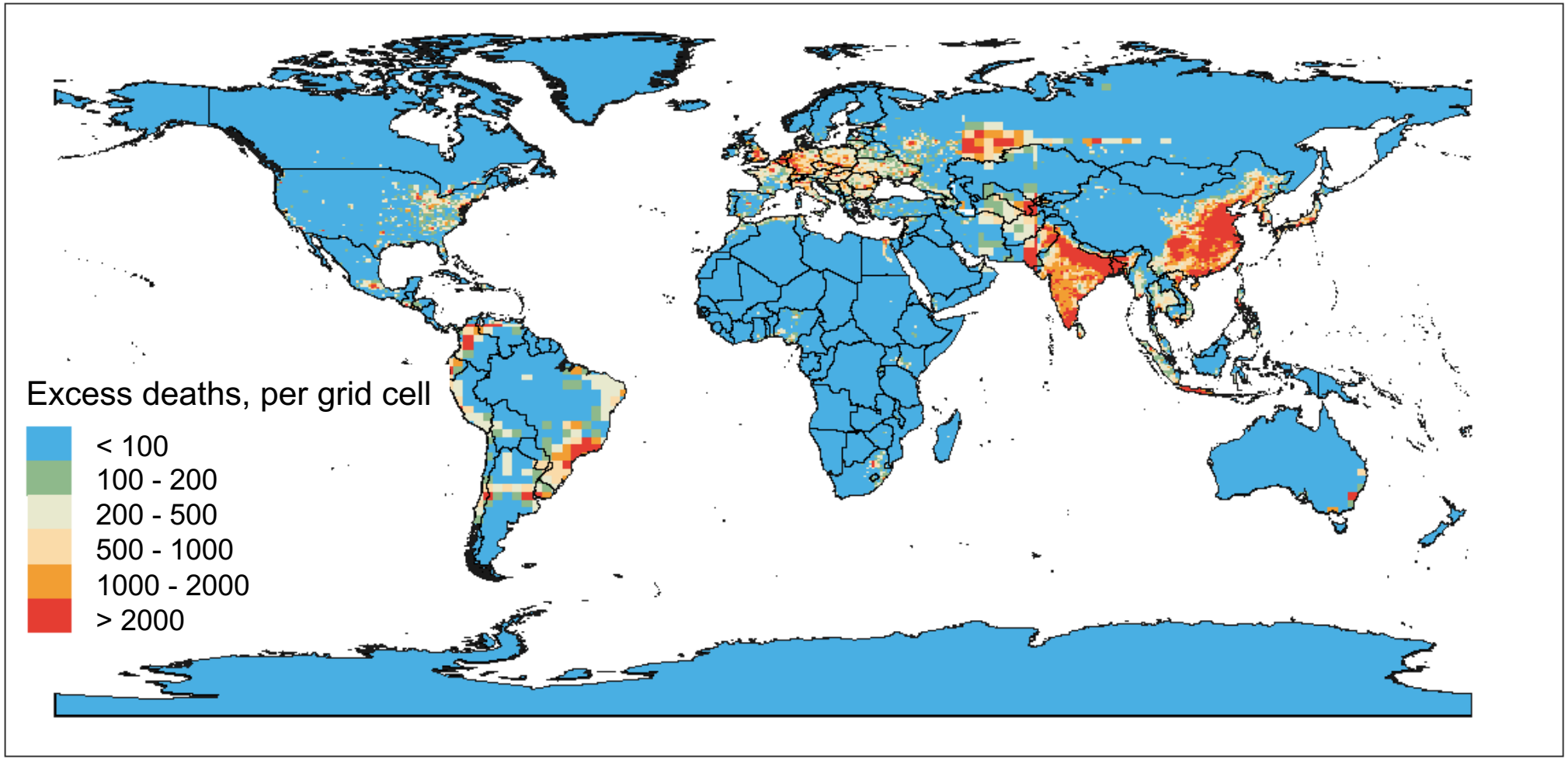
Meta-analysis CRF from cohort studies



Global mortality estimates

We use the derived fossil-fuel $PM_{2.5}$ with baseline mortality in the meta-analysis CRF to estimate global mortality

Estimated global mortality from fossil-fuel combustion

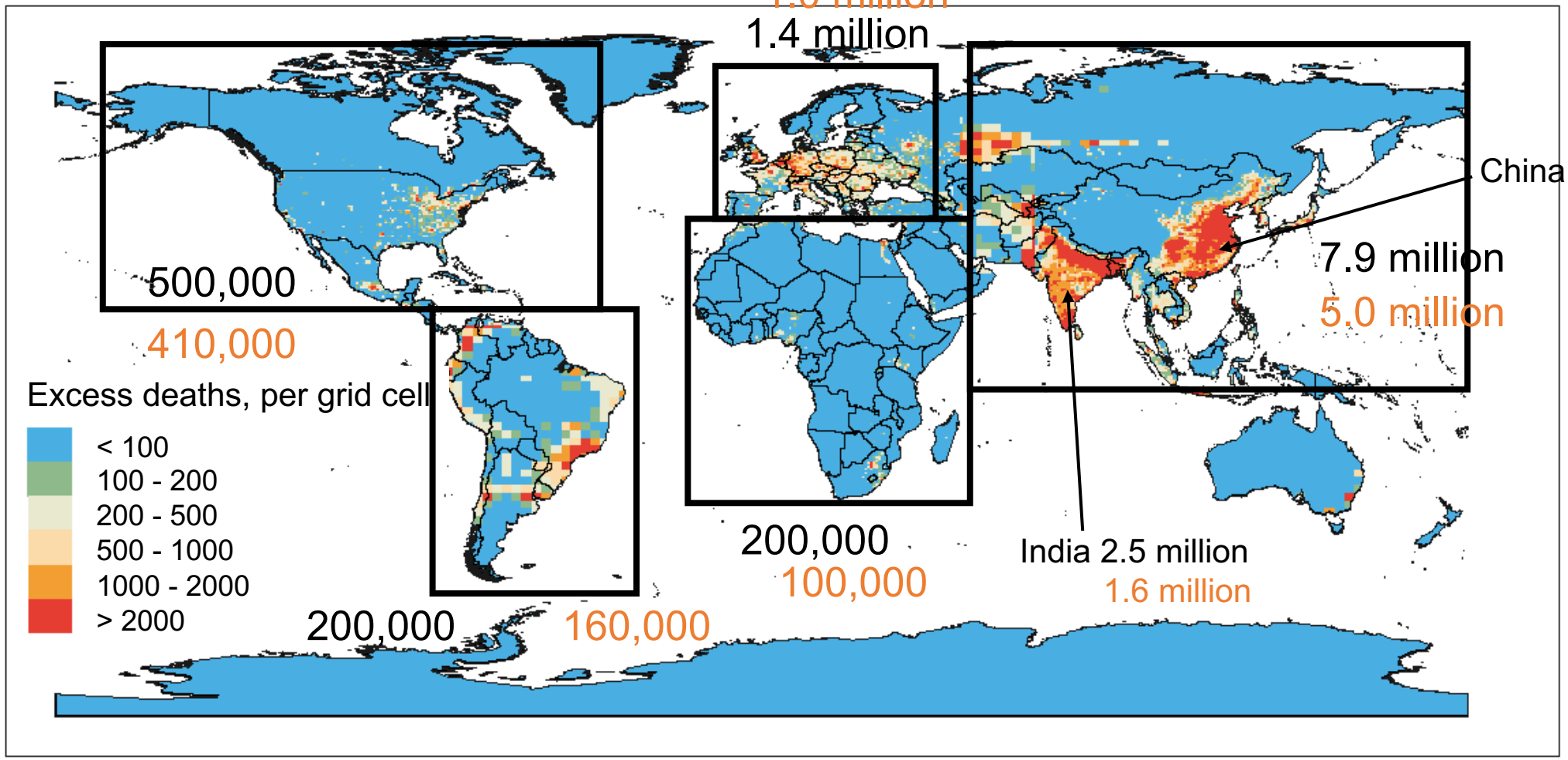


10.2 million deaths attributed to fossil-fuel $PM_{2.5}$ in 2012

[-47 million, 17 million]

[Vohra et al., in review, *Environ. Res.*]

Estimated global mortality from fossil-fuel combustion

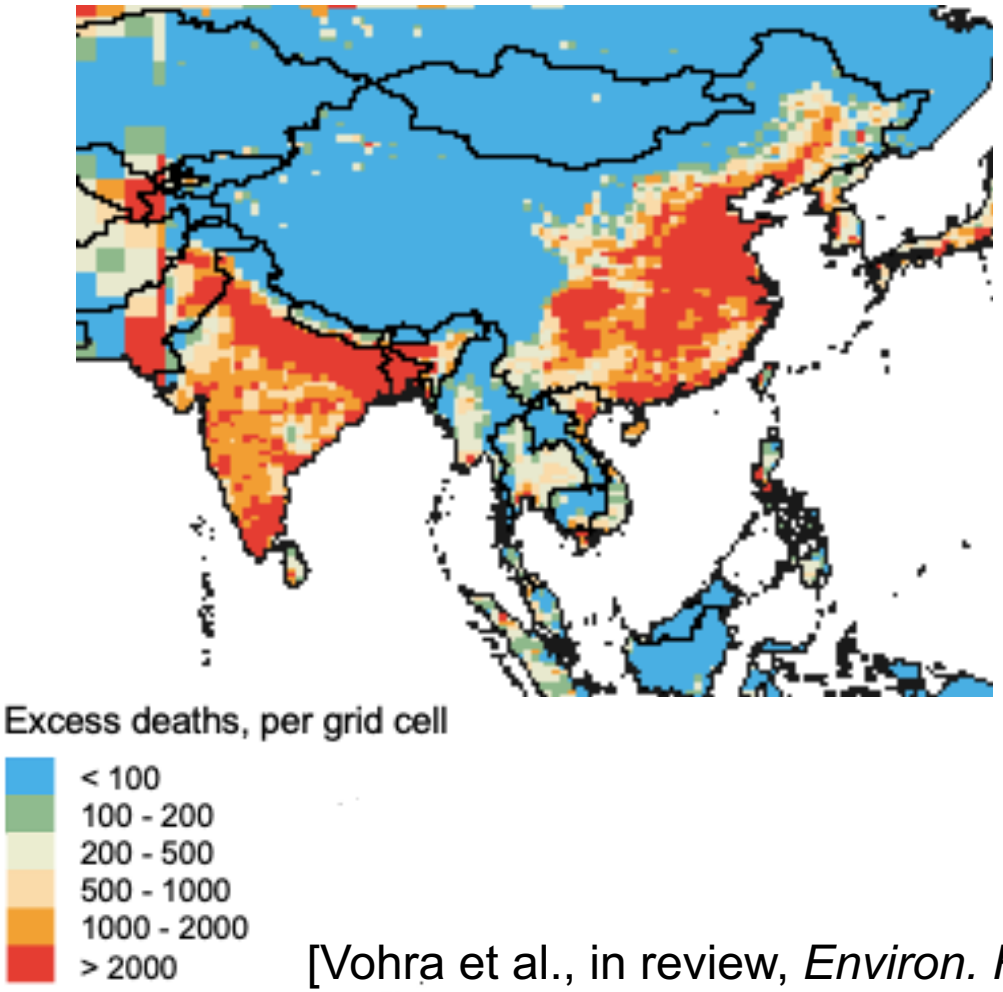


10.2 million deaths attributed to fossil-fuel $PM_{2.5}$ in 2012

[-47 million, 17 million]

[Vohra et al., in review, *Environ. Res.*]

Estimated global mortality from fossil-fuel combustion



[Vohra et al., in review, *Environ. Res.*]

2012

China : 3.9 million

Global : 10.2 million

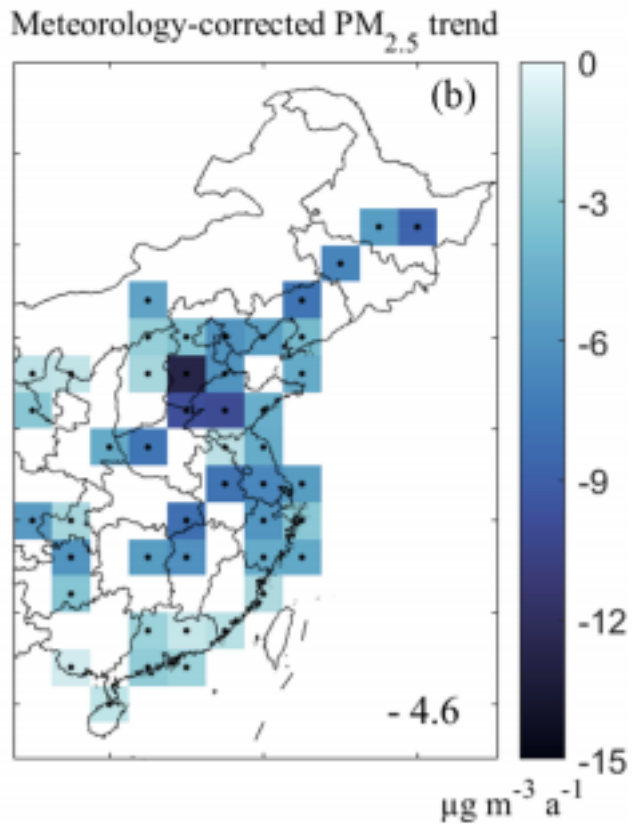
43.7% reduction in $PM_{2.5}$ across China

2018

China : 2.4 million

Global : 8.7 million

$PM_{2.5}$ trends (2013-2018)



30-50% decline in China

[Zhai et al., 2019]

Dramatic reduction in $PM_{2.5}$ levels in China decreases premature deaths by 1.5 million; no evidence observed for India yet

Conclusions

- We estimate global mortality of **10.2 million** in 2012 from fossil-fuel $PM_{2.5}$ derived using a chemical transport model GEOS-Chem and meta-analysis CRF
- Greatest mortality impact is estimated for regions with substantial fossil-fuel $PM_{2.5}$, notably China (**~3.9 million**) and India (**~2.5 million**) in 2012. Estimates for China decrease to ~2.4 million in 2018 because of decline in fossil fuel emissions
- Our estimates for fossil-fuel related $PM_{2.5}$ are higher than premature mortality estimates from total $PM_{2.5}$ mainly because of the choice of CRF

Any questions? kxv745@bham.ac.uk @kohra_thefog