Atmospheric Composition and Air Quality Group

Group website: https://maraisresearchgroup.co.uk/

25 February 2022

GEOG0012

Dr Eloise A Marais

What is Air Pollution?

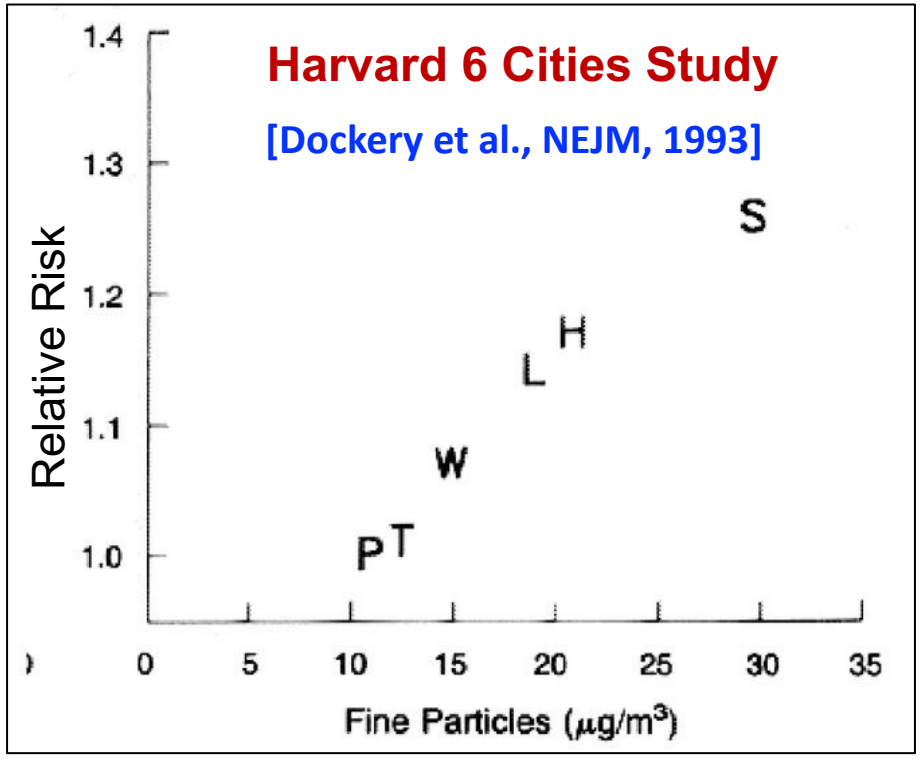
Release of gases and particles to the atmosphere that have a negative impact on our health and the built and natural environment

Many cities like Delhi experienced sustained clean air for the first time in years during COVID-19 lockdowns

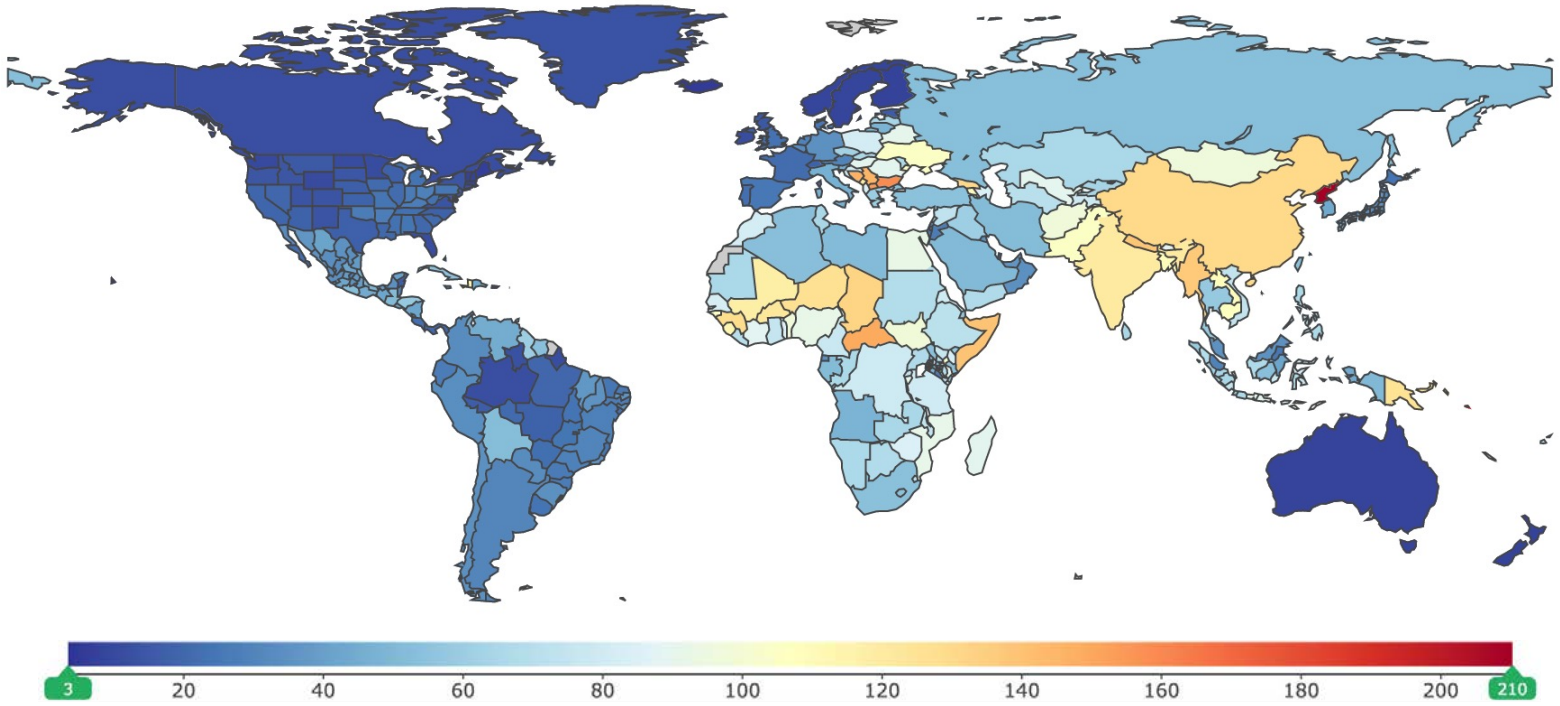
Typical Criteria Pollutants:

Benzene
Formaldehyde
Ozone (**O_3**)
Nitrogen dioxide (**NO_2**)
Fine particles (**$PM_{2.5}$**)
Carbon monoxide (**CO**)
Lead (**Pb**)
Sulfur dioxide (**SO_2**)

Hazardous Effects of Air Pollution



Death rates from exposure to air pollution (per 100,000)



[http://www.healthdata.org/gbd/data-visualizations]

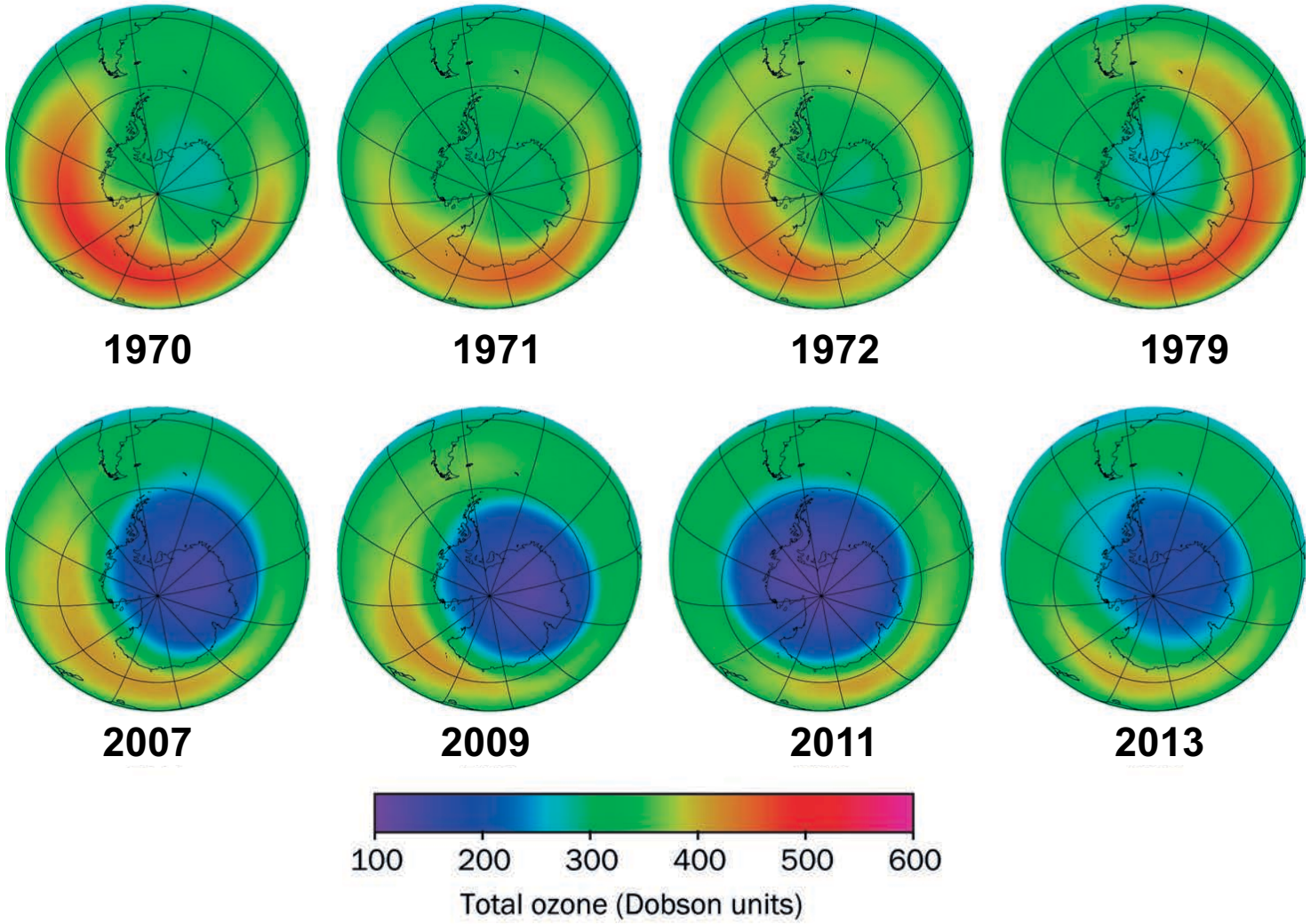
The more we study air pollution, the more we discover about its ill effects on health:

Lung cancer, respiratory disease, cognition, eyesight, dementia, diabetes, lung development, mortality

Hazardous Effects of Air Pollution

Ozone: Good Up High, Bad Nearby

Loss of Ozone in the Stratosphere (>10 km altitude) over Antarctica



[https://climate.nasa.gov/internal_resources/1916/]

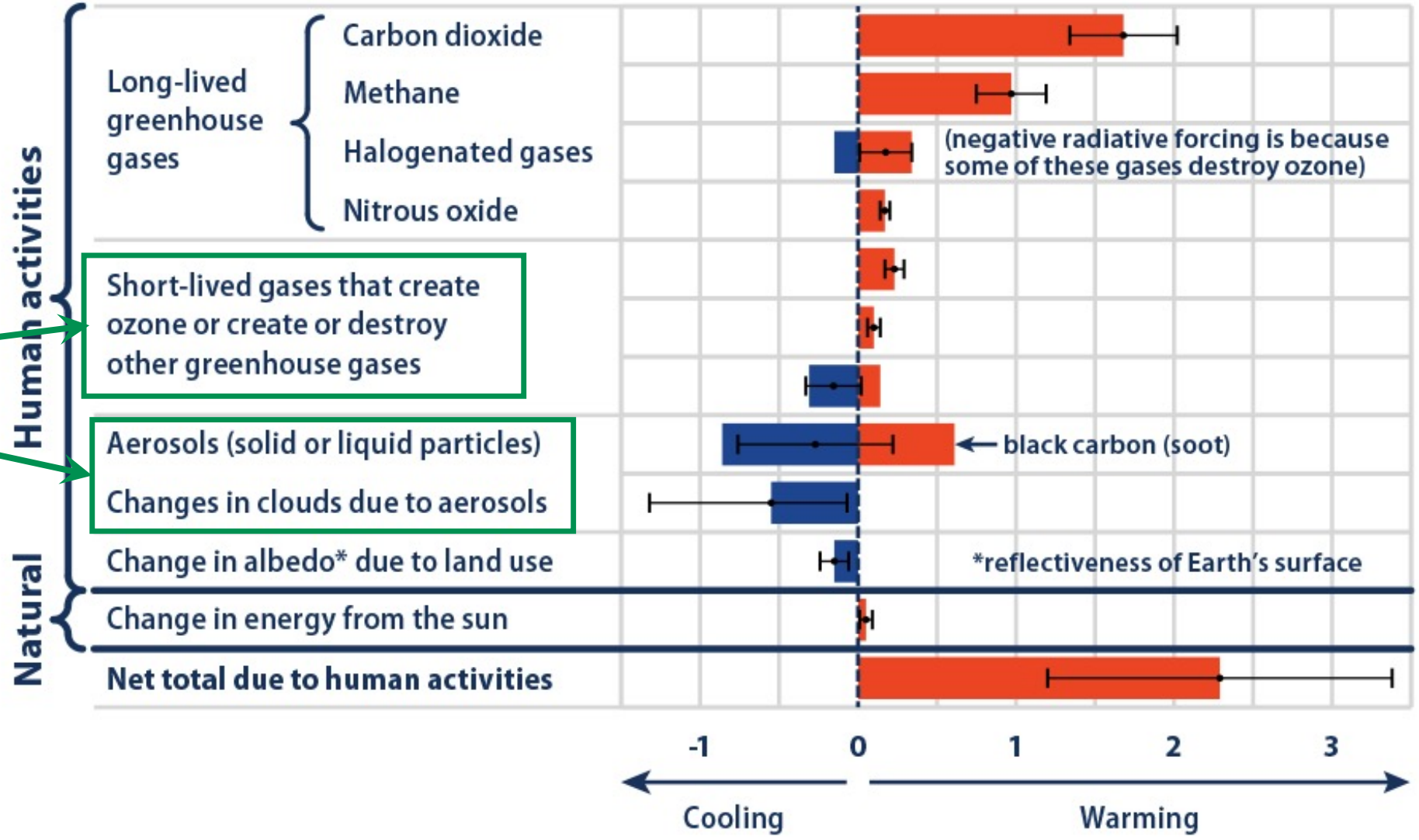
Surface Ozone Damage to Plants

Concern for crop yields, food security, economic losses, ecosystem services (reliance on vegetation for livelihood and/or wellbeing)

Hazardous Effects of Air Pollution

Warming and cooling effects of human activities since 1750

Climate effect of air pollutants (or short-lived climate forcers)



[https://www.epa.gov/climate-indicators/climate-change-indicators-climate-forcing]

Public Concern over Air Pollution

Air pollution is in the public consciousness, as indicated by routine reporting in leading newspapers

News | Opinion | Sport | Culture | Lifestyle | More

Environment ▶ Climate crisis Wildlife Energy Pollution

Air pollution

February 2022

Doctors urge Sadiq Khan to cancel Silvertown tunnel over pollution fears

24 Feb 2022

Poorest Londoners most at risk from toxic air, Sadiq Khan says

17 Feb 2022

Air pollution may affect sperm quality, says study

17 Feb 2022

Wood burners emit more particle pollution than traffic, UK data shows

15 Feb 2022

Pollutionwatch / Pollutionwatch: concerns over ultrafine particles from aircraft

11 Feb 2022 40

Uber backs Sadiq Khan's road-charging proposals for London

8 Feb 2022

Greater Manchester clean air zone rollout delayed until summer

4 Feb 2022

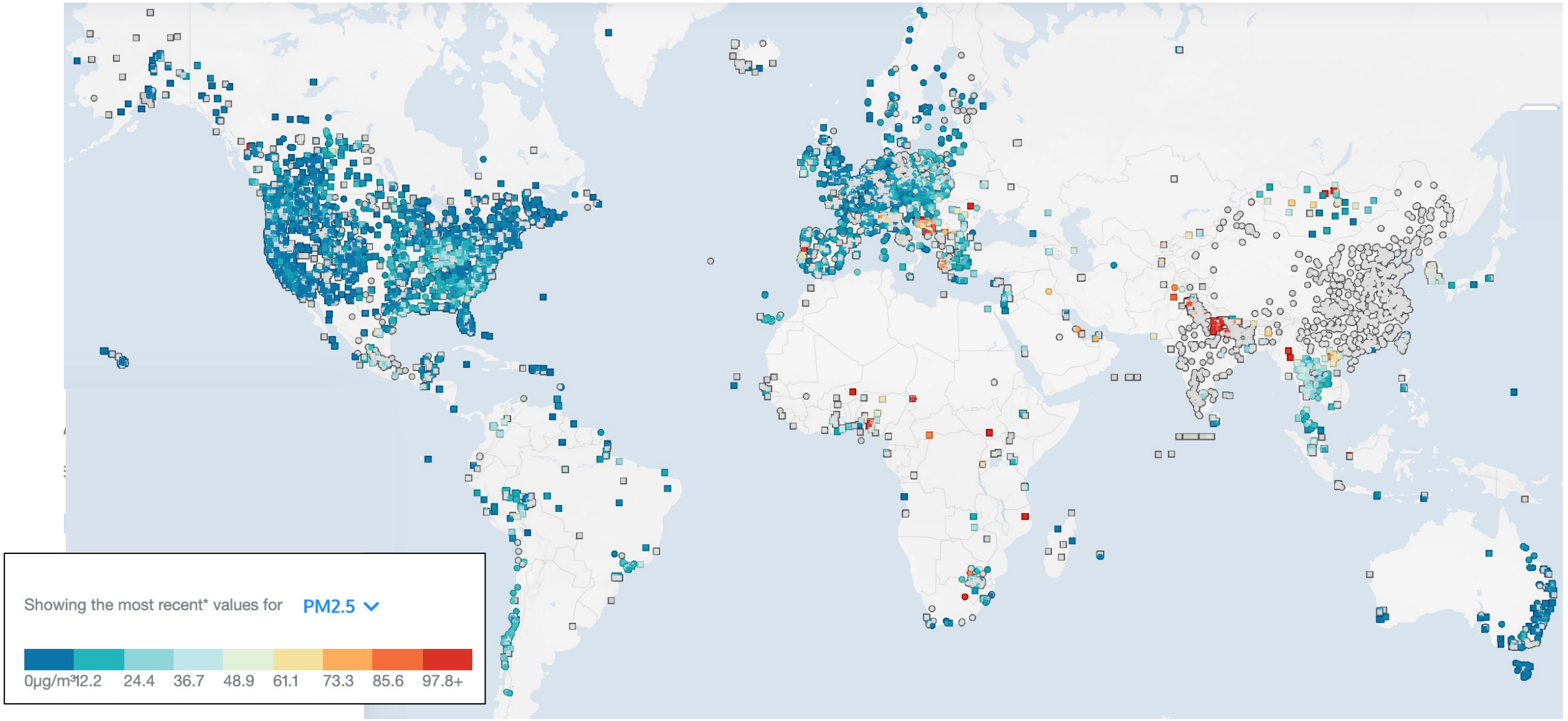
America's dirty divide / Texas says it doesn't monitor pollution spikes, calling it 'often unnecessary'

3 Feb 2022

[https://www.theguardian.com/environment/air-pollution]

Ongoing Research is Vital

Large data and knowledge gaps in rapidly developing countries with unenforced air quality policy

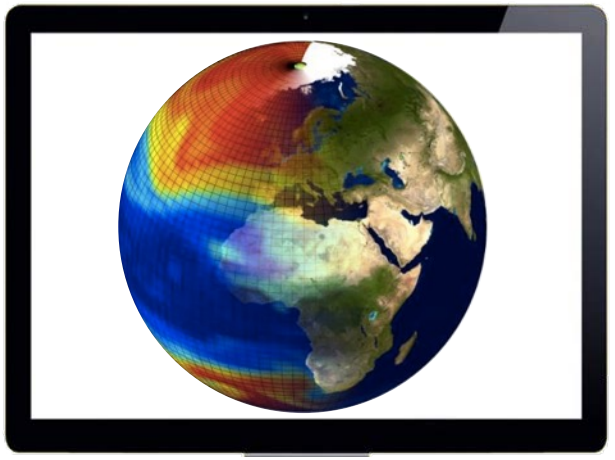


[https://openaq.org/#/map]

UCL Geography Air Pollution Research

The tools we use and develop to address uncertainties and inform policy.

CHAMBER



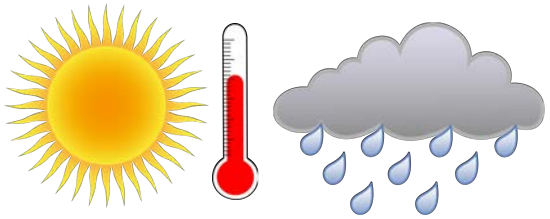
3D ATMOSPHERIC CHEMISTRY MODEL

SATELLITES

IN SITU

UCL Geography Air Pollution Research

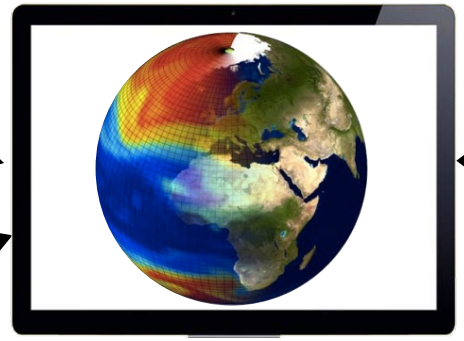
Model: computer code to represent our best understanding of atmospheric chemistry in 3D



Meteorology

Emissions (natural/human)
(*includes temporal variability*)

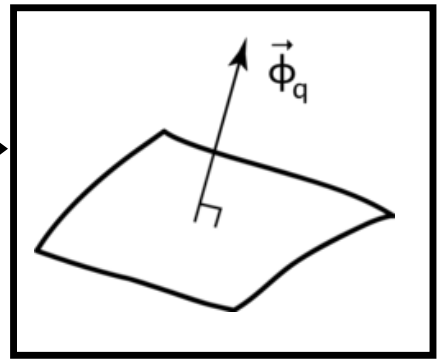
3D MODEL



Chemistry
Transport
Dry/wet deposition

Calculates **air pollution** concentrations

Radiative Transfer Model



Energy budget

Calculates **climate changes**

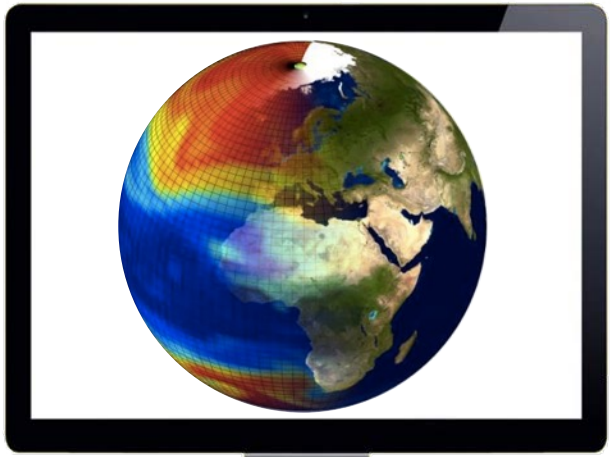
To find out more about GEOS-Chem: http://acmg.seas.harvard.edu/geos/index.html

UCL Geography Air Pollution Research

Observations:

improve and validate models, but models also help us interpret the observations

CHAMBER



3D ATMOSPHERIC CHEMISTRY MODEL

SATELLITES

IN SITU

The Skills Gained from Computational Air Pollution Research

- Fundamental knowledge of atmospheric chemistry and air quality
- Data management, analysis, and visualization
- Computer programming
- Written and spoken science communication
- Organizational skills required of any professional setting: time management, team work, networking

These Skills are Valued in Multiple Sectors

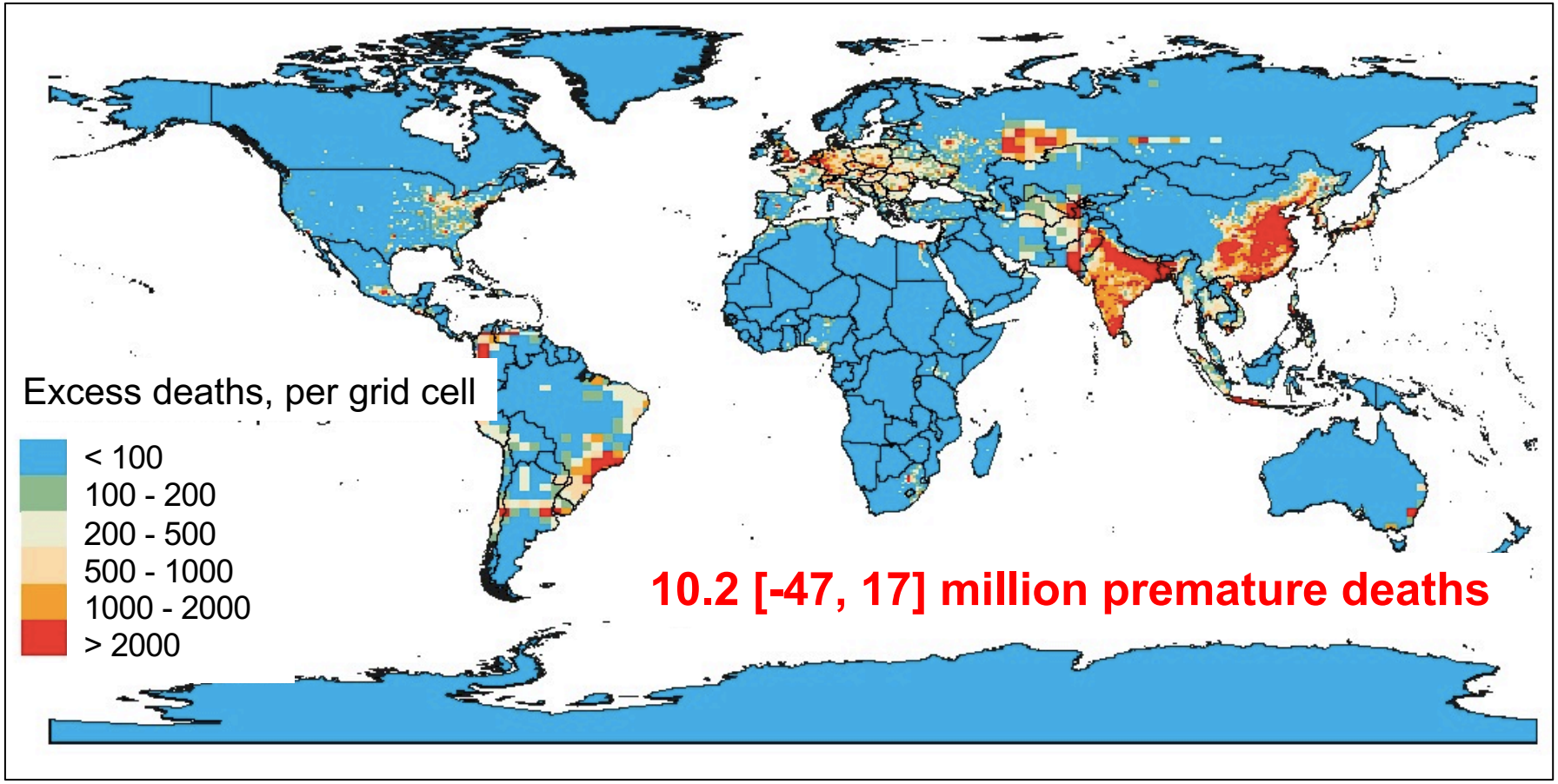
- Data scientist (highly sought after)
- Research
- Education
- Environment
- Policy
- Energy, Industry, Transport

Take a look at the range of careers of alumni from the group where I obtained my PhD:
http://acmg.seas.harvard.edu/alumni_list.html

Recent and Current Research Projects in the UCL Atmospheric Chemistry and Air Quality Group

Fossil Fuels and Global Health

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



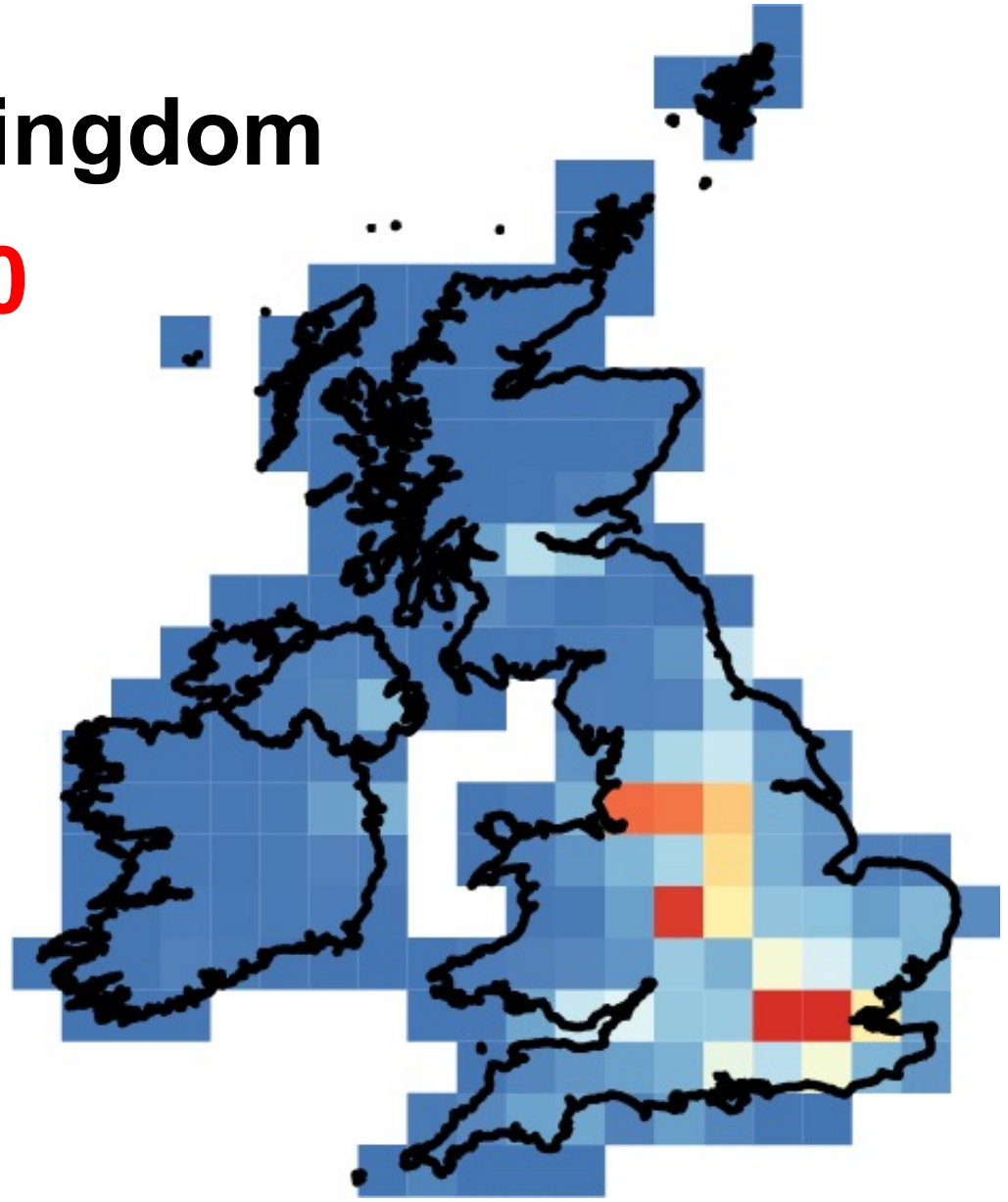
Number of lives lost each year equivalent to the population of Greater London

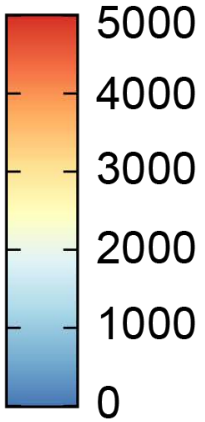
[Vohra et al., 2021]

Premature mortality from fossil fuel combustion in the UK

United Kingdom

99,000



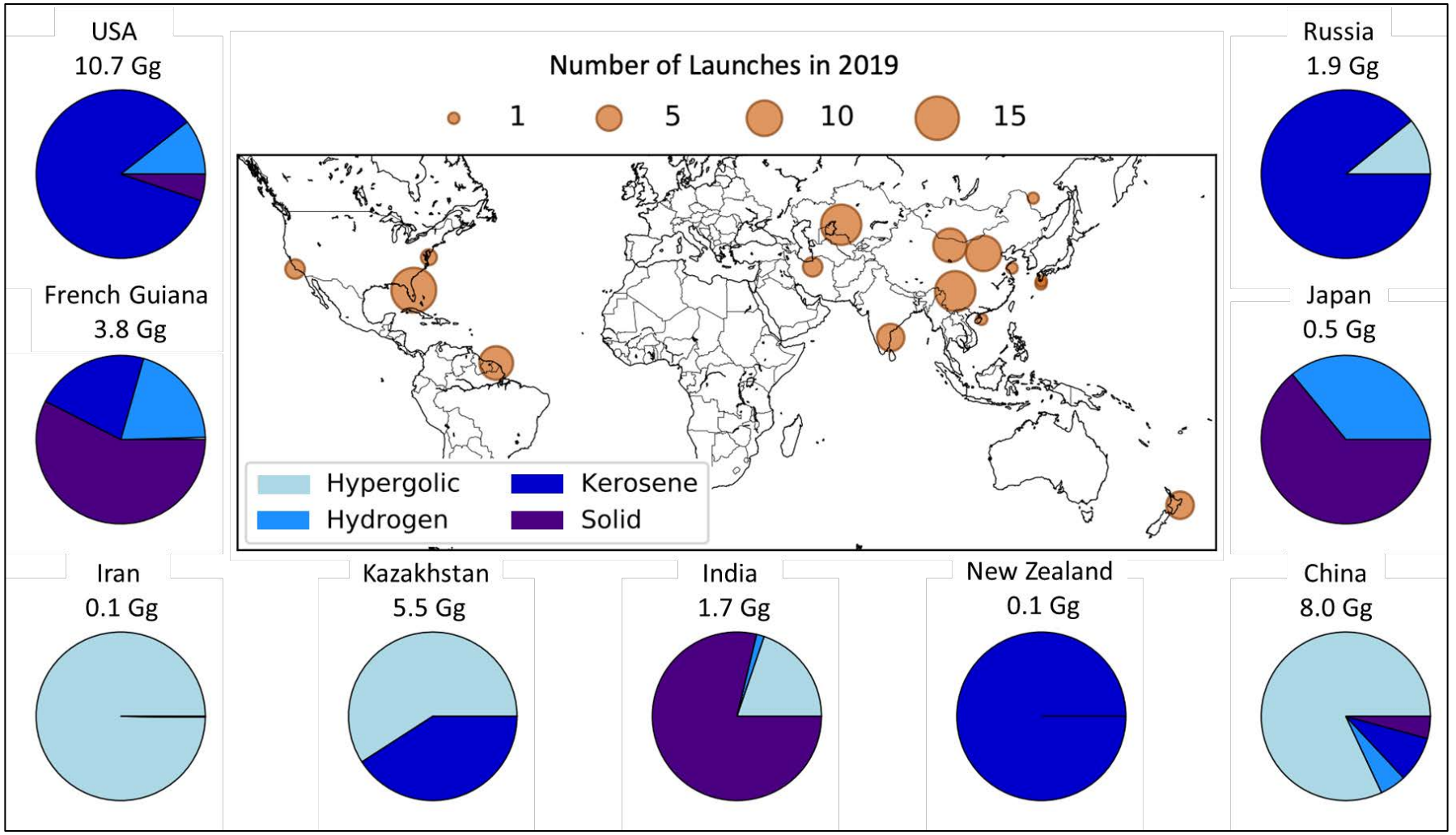


Premature deaths per grid box
(50 km latitude x 67 km longitude)

[Vohra et al., 2021]

Rockets and Air Pollution

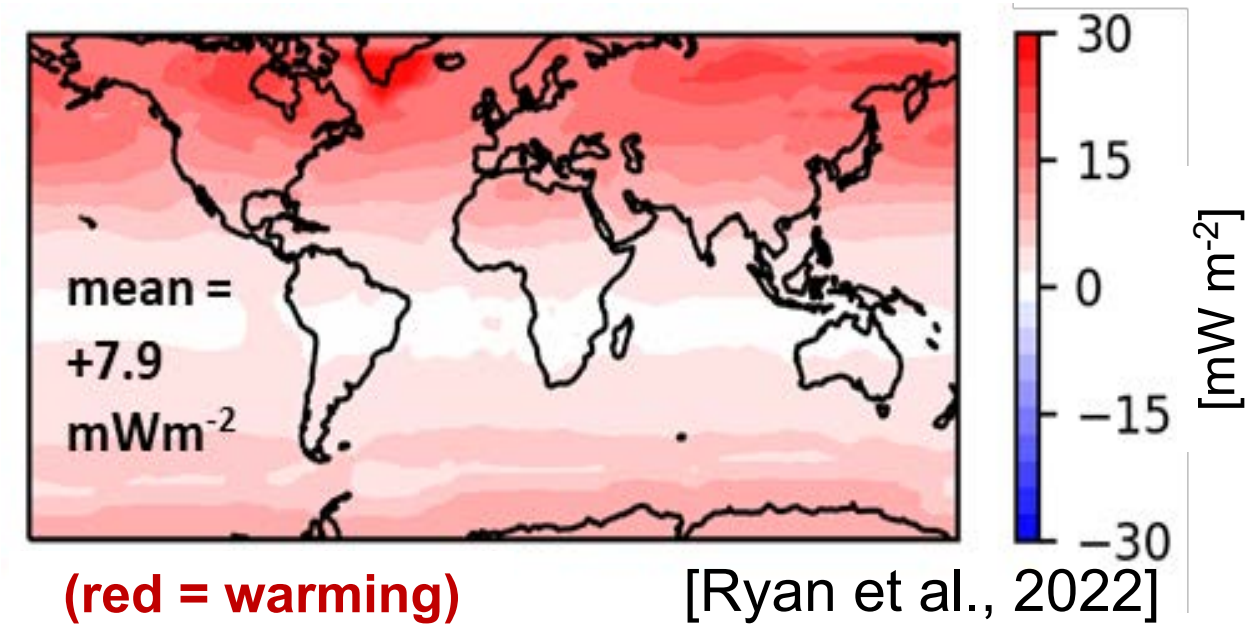
The modern space race includes more diverse countries and launch sites than the first space race



[Ryan et al., 2022]

Space Tourism and Air Pollution

Spatial distribution of radiative forcing due to space tourism emissions of black carbon (**soot**)



(red = warming) [Ryan et al., 2022]

Soot from rockets 500-times higher warming efficiency than other soot sources

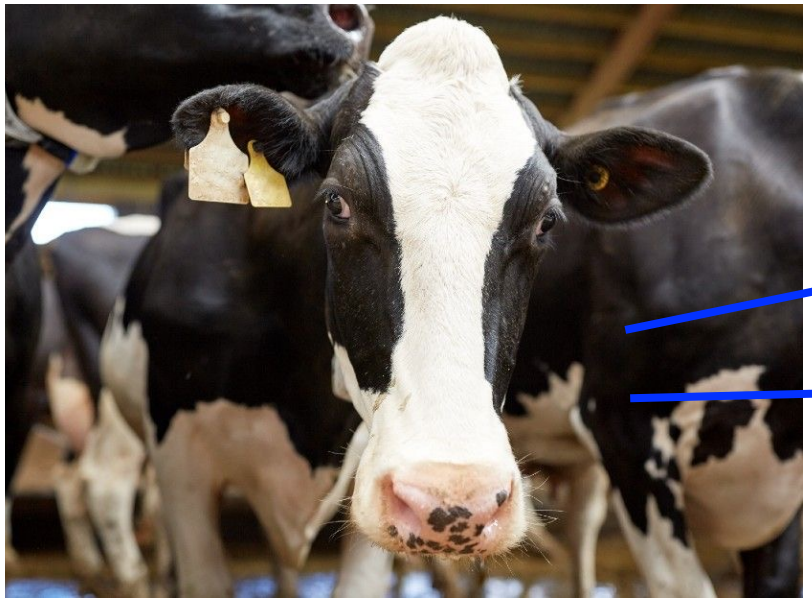
More on this topic:

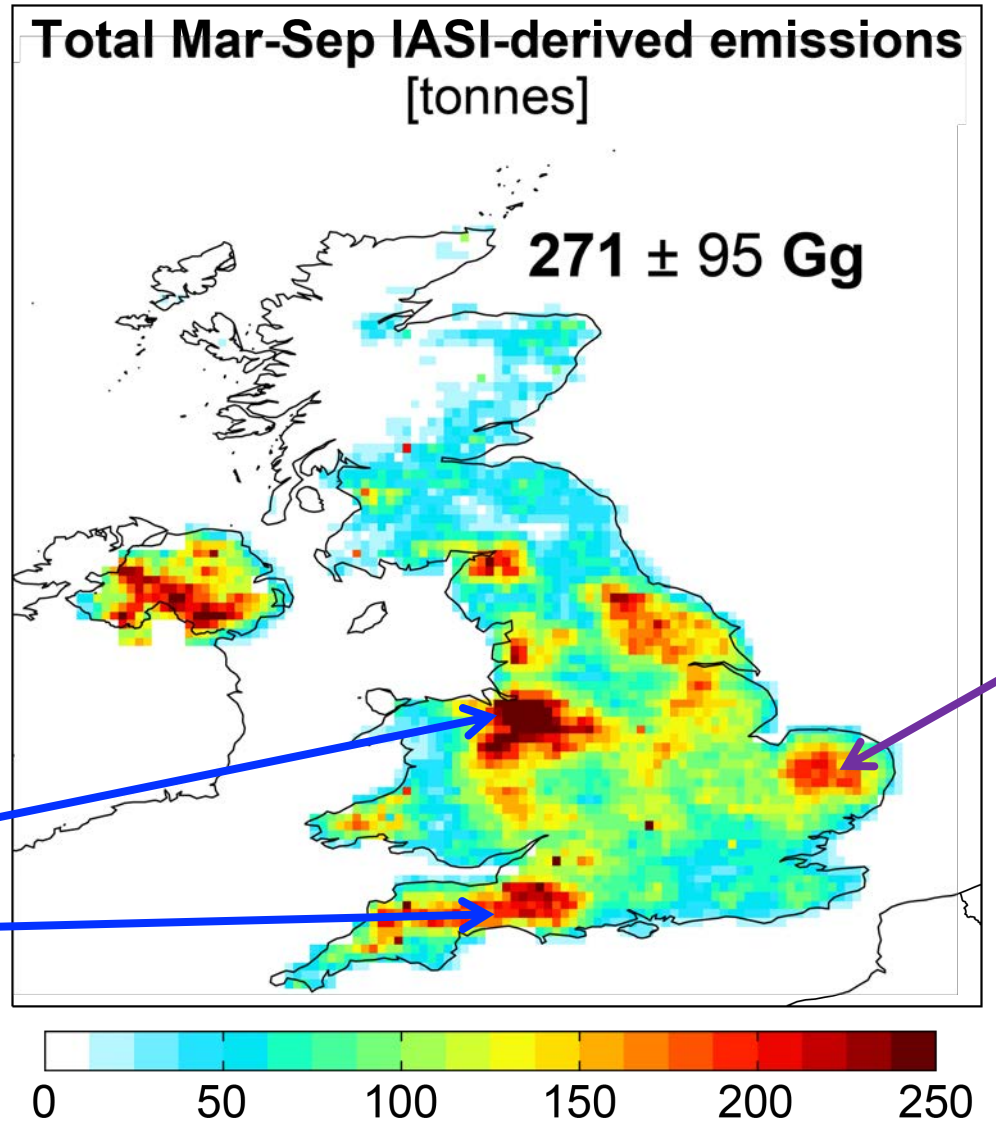
The Conversation: https://theconversation.com/space-tourism-rockets-emit-100-times-more-co-per-passenger-than-flights-imagine-a-whole-industry-164601

UCL Lunch Hour Lecture: https://www.youtube.com/watch?v=-0HhW1-ybA4

Pollution from UK Agriculture

Emissions of ammonia (NH_3) from agriculture estimated with satellite observations and a model





[Marais et al., 2021]

An emerging source: Power barges (powerships)

Natural gas operated powerships

Generating capacity has increased 13-fold in a decade

A popular quick to install gas-to-electricity option in Africa, Asia, the Middle East and the Caribbean.

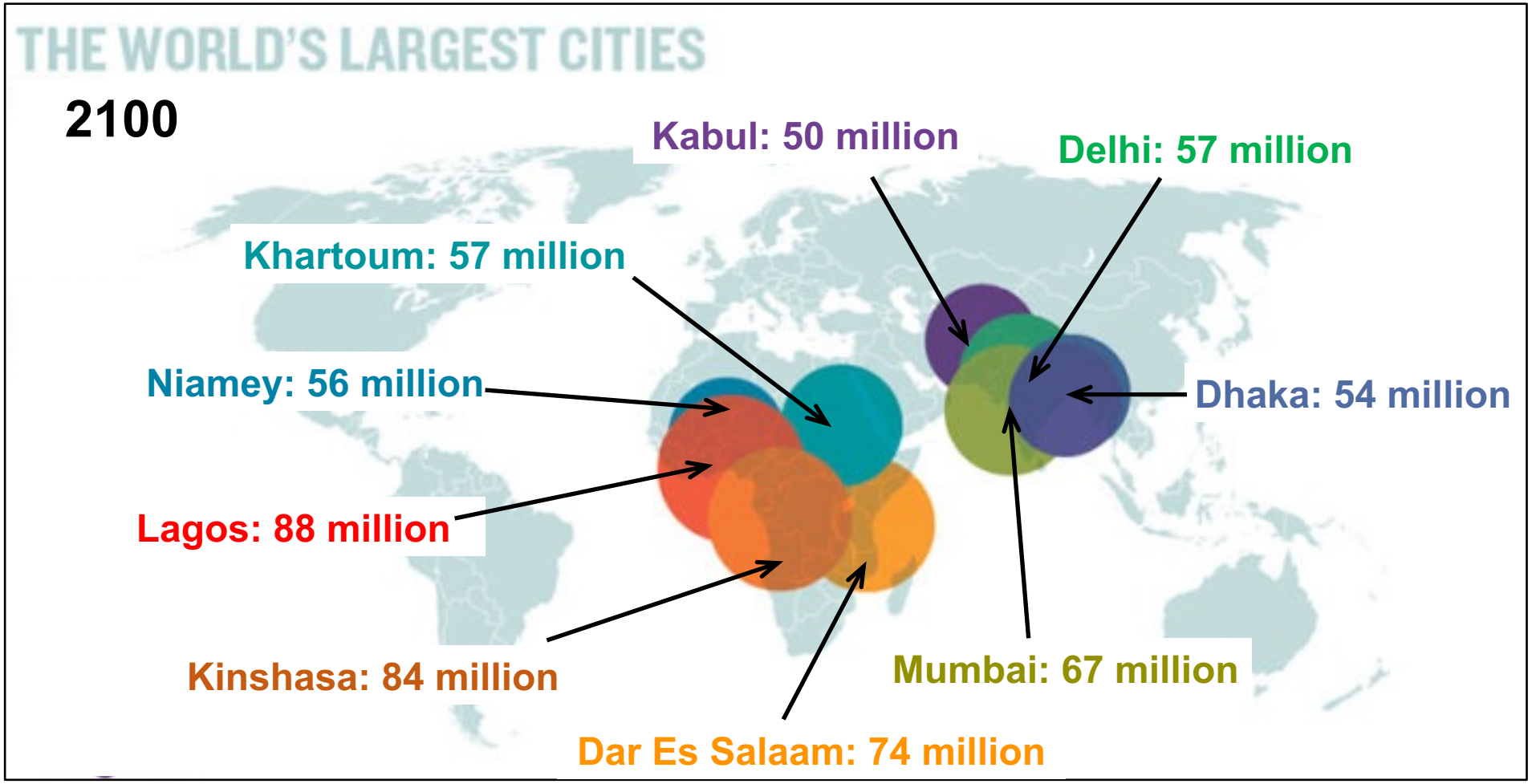
Emission factor and local air pollution and methane leakage measurements are needed to assess influence on air quality and climate

[Marais et al., 2022]

Megacities of the future

By 2100, most of the largest cities will be in tropical Africa and Asia

Greatest air quality knowledge gaps are in African megacities (WHO, 2021)

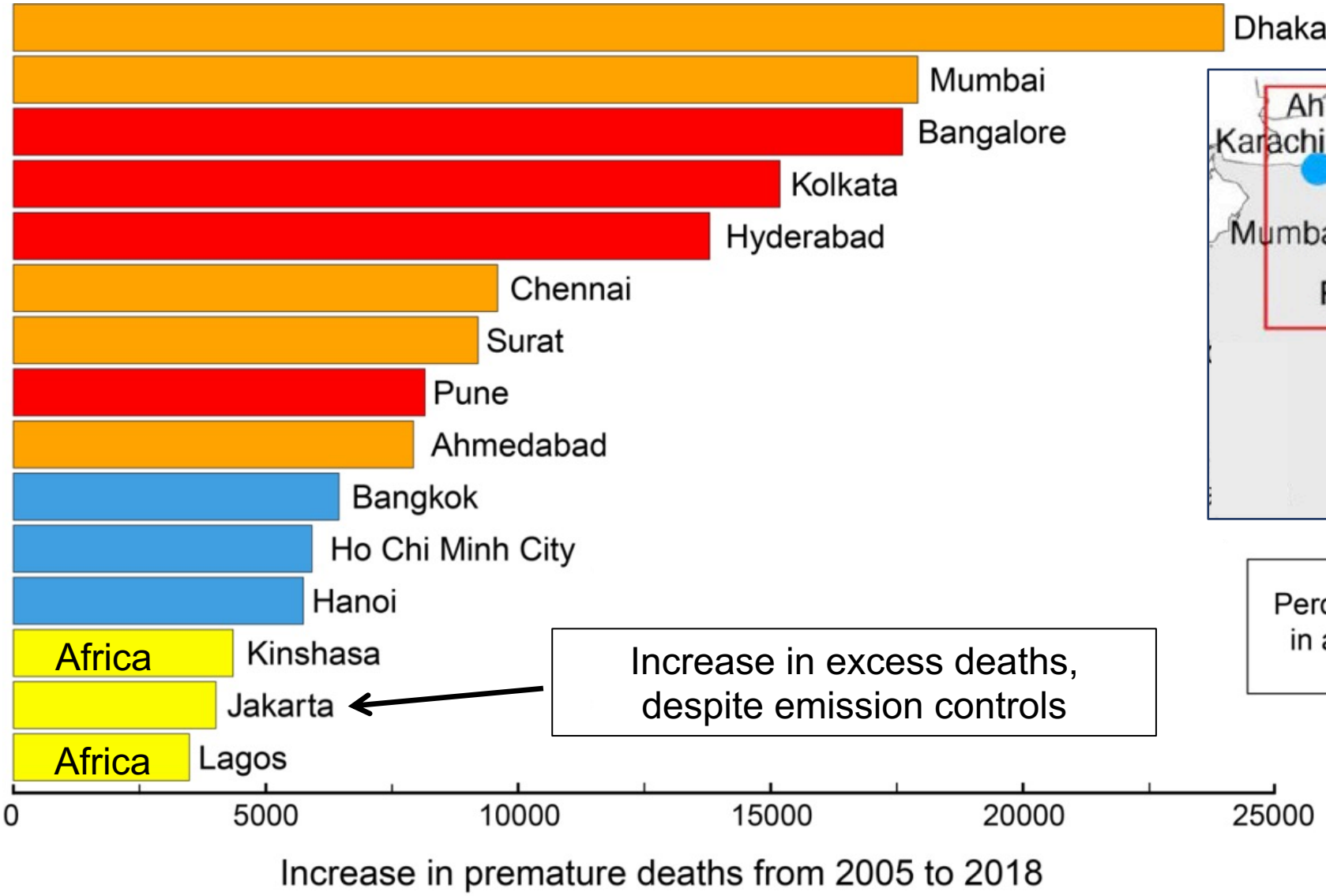


Largest cities in 2020 (population in millions):

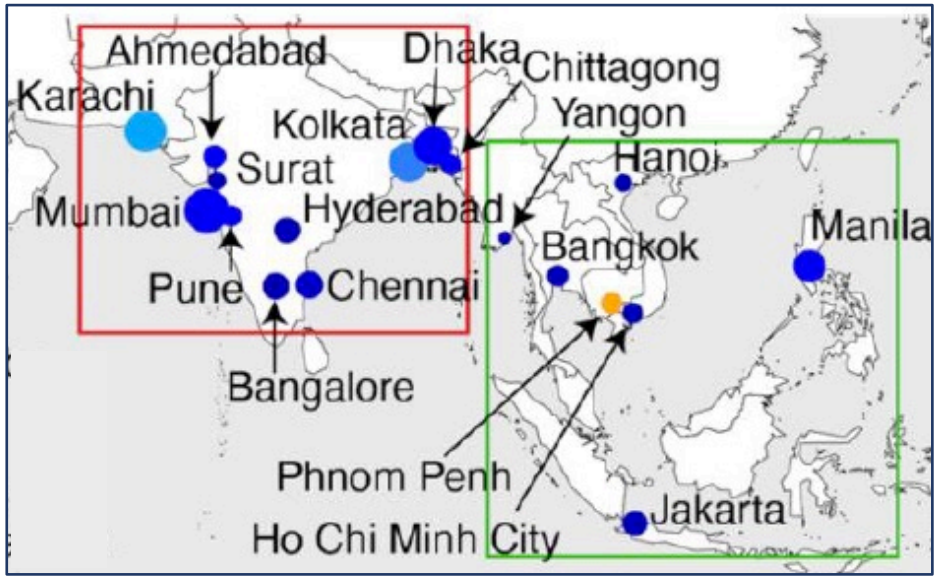
1. Tokyo (38)
2. Delhi (29)
3. Shanghai (26)
4. Sao Paulo (22)
5. Mexico City (22)
6. Cairo (20)
7. Mumbai (20)
8. Beijing (20)
9. Dhaka (20)
10. Osaka (19)

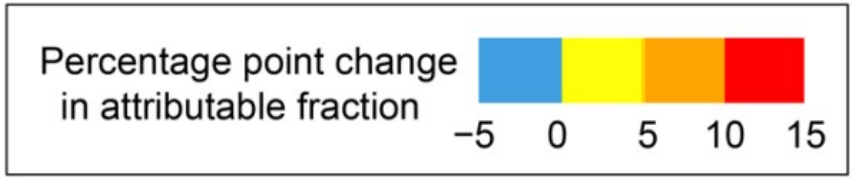
Adapted image: https://medium.com/ensia/here-come-the-megacities-1b0f8a2287f2
Projections: https://journals.sagepub.com/doi/full/10.1177/0956247816663557

Premature mortality from air pollution in fast-growing tropical cities



Increase in excess deaths, despite emission controls





Total: 179,550

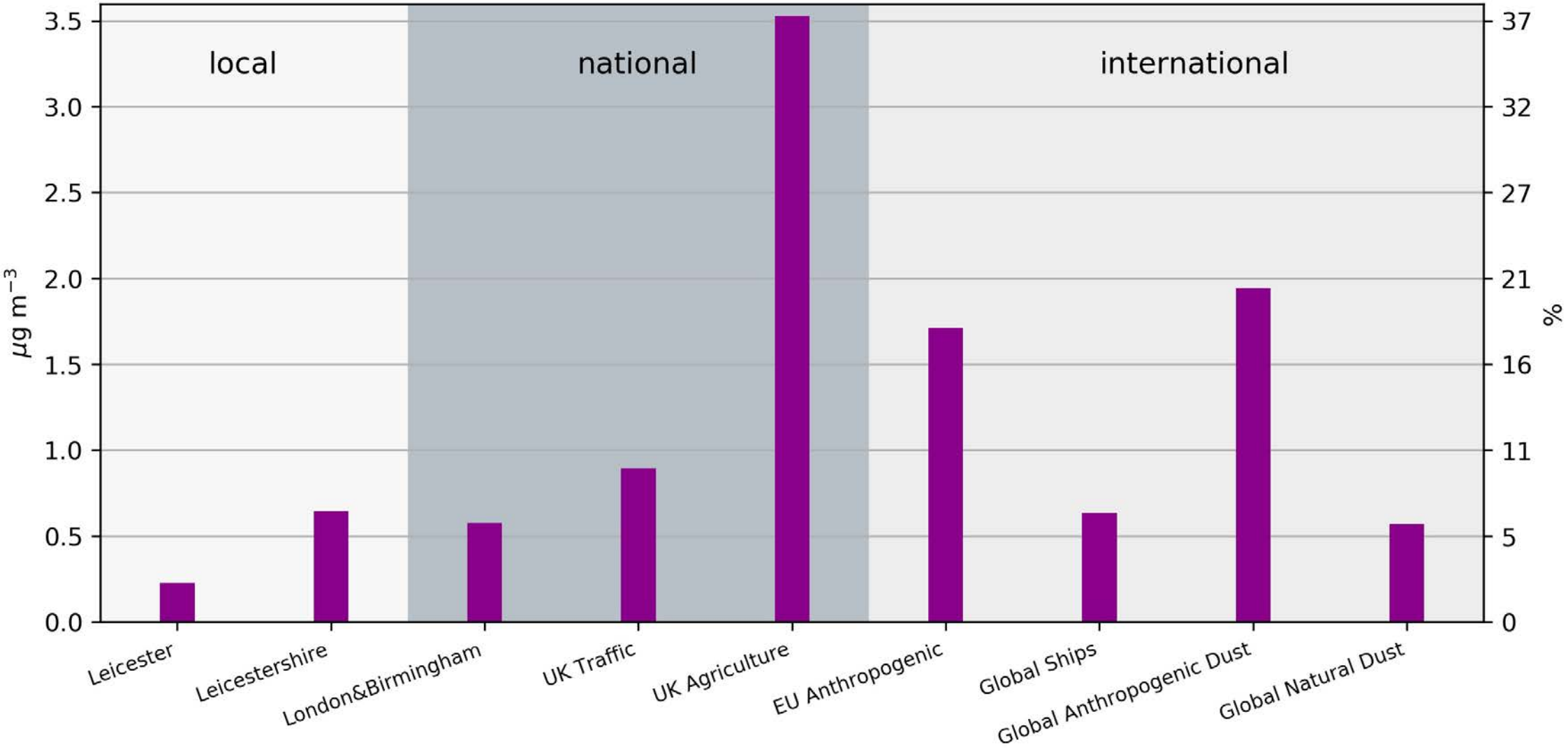
[95% CI: -227,131 to 586,231]

Highest ranked are almost all in Asia.

Africa likely to be ranked higher for adverse health effects of increases in exposure to NO_2

Aiding local authorities develop air quality policies

Use a model to determine the sources and regions that contribute to particulate pollution in Leicester



Particle pollution in Leicester dominated by agriculture, not local sources

Summary

- Air pollution comes from gases and aerosols released into the atmosphere
- Air pollution has adverse effects on our health, the built and natural environment, and food security, and alters the energy balance of the Earth (climate)
- Ongoing research is needed to estimate air quality in regions without measurements and to address uncertainties in our understanding of the sources and processes that contribute to degradation in air quality
- The air pollution research group at UCL uses a diverse range of research tools
- As a result, project topics range from local to regional to global air pollution
- We work with policymakers, local and national government, other research agencies, and the commercial sector to address urgent societal issues
- Skills gained from conducting this research are sought after in many sectors

All papers referenced in the talk are here: http://maraisresearchgroup.co.uk/publications.html