Air pollution and health in the UK, and the impact of policy measures over the last 50 years

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Air pollution is an evolving problem

Changes in exposure over time

Soot, coal burning, sulphur dioxide

Leaded petrol

Diesel engines, NO_2, ozone, carbon monoxide

Biomass burning, indoor air, climate change, forest fires

Environmental Research Letters

OPEN ACCESS

RECEIVED
8 January 2019

REVISED
29 March 2019

ACCEPTED FOR PUBLICATION
2 April 2019

PUBLISHED
26 June 2019

LETTER

Modelling public health improvements as a result of air pollution control policies in the UK over four decades—1970 to 2010

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Keywords: air pollution, long-term trends, attributable mortality, respiratory health

Method

Use atmospheric chemistry model to simulate air quality in the UK in 1970, 1980, 1990, 2000 and 2010 at 5km resolution

Driven by anthropogenic emissions only, meteorology fixed for each year

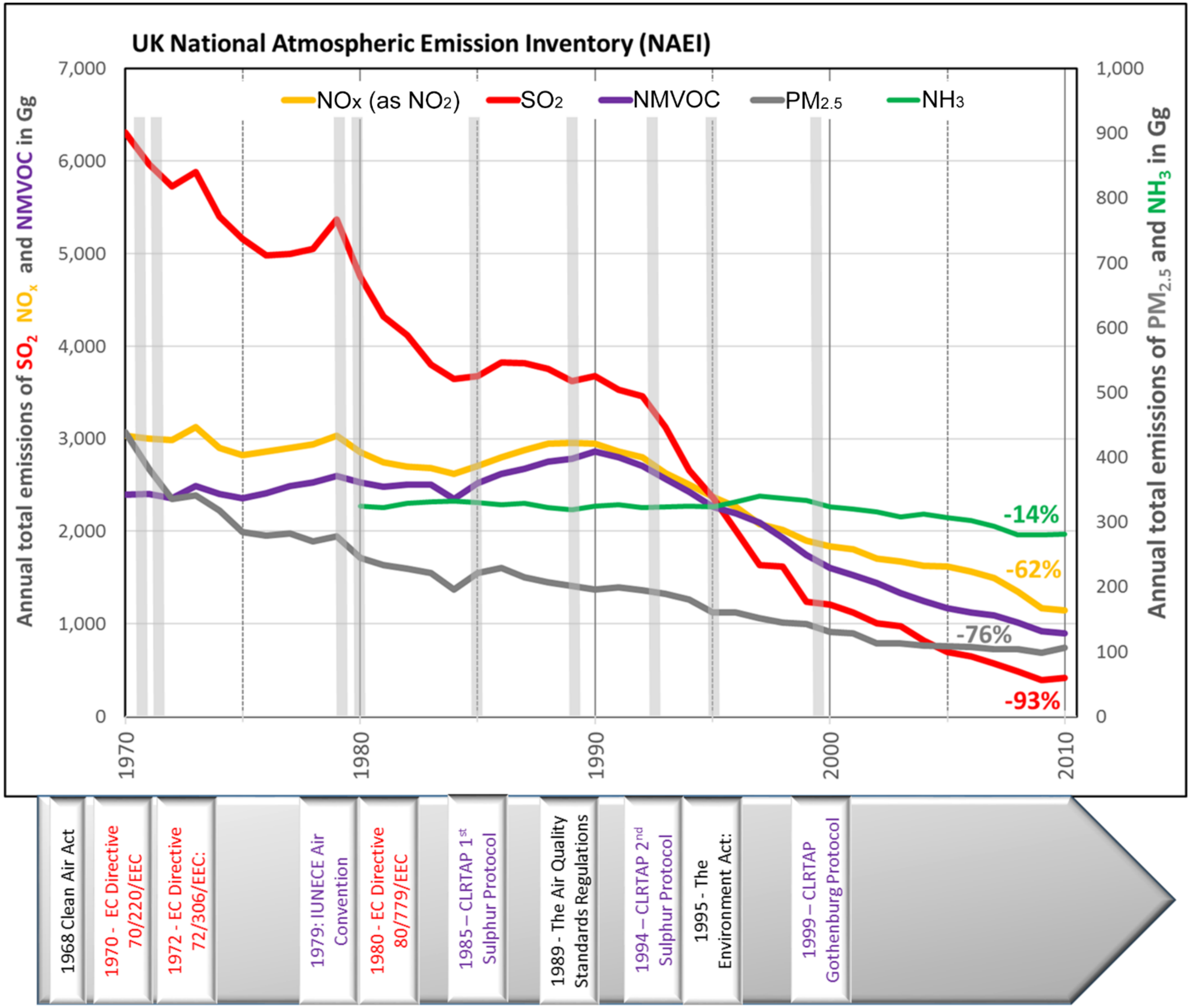
Calculate population weighted concentrations of a range of air pollutants and calculate health impact (attributable fraction of mortality)

Emissions of key pollutants from 1970 to 2010

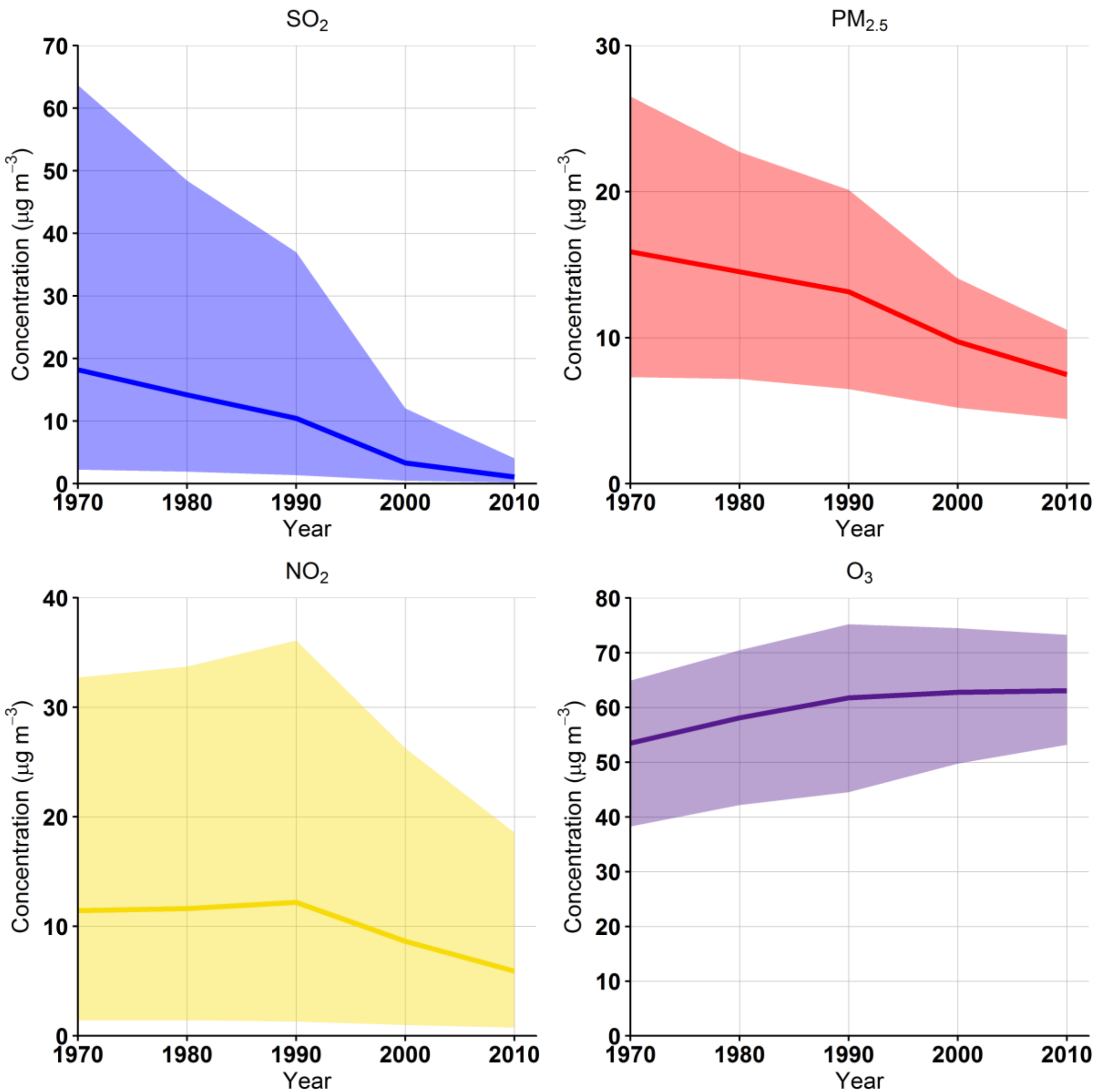
Early policies focused on **sulphur dioxide** emissions and stationary sources *(e.g. coal power plants, industry)*

Nitrogen oxide and **volatile organic compound** emissions increased with vehicle numbers until 1990s, then declined as a result of more stringent limit values for vehicles *(e.g. 3-way catalyst, EURO standards)*

Fine particulate matter emissions declined throughout, while **ammonia** emissions show only modest reduction



Modelled concentrations of key pollutants

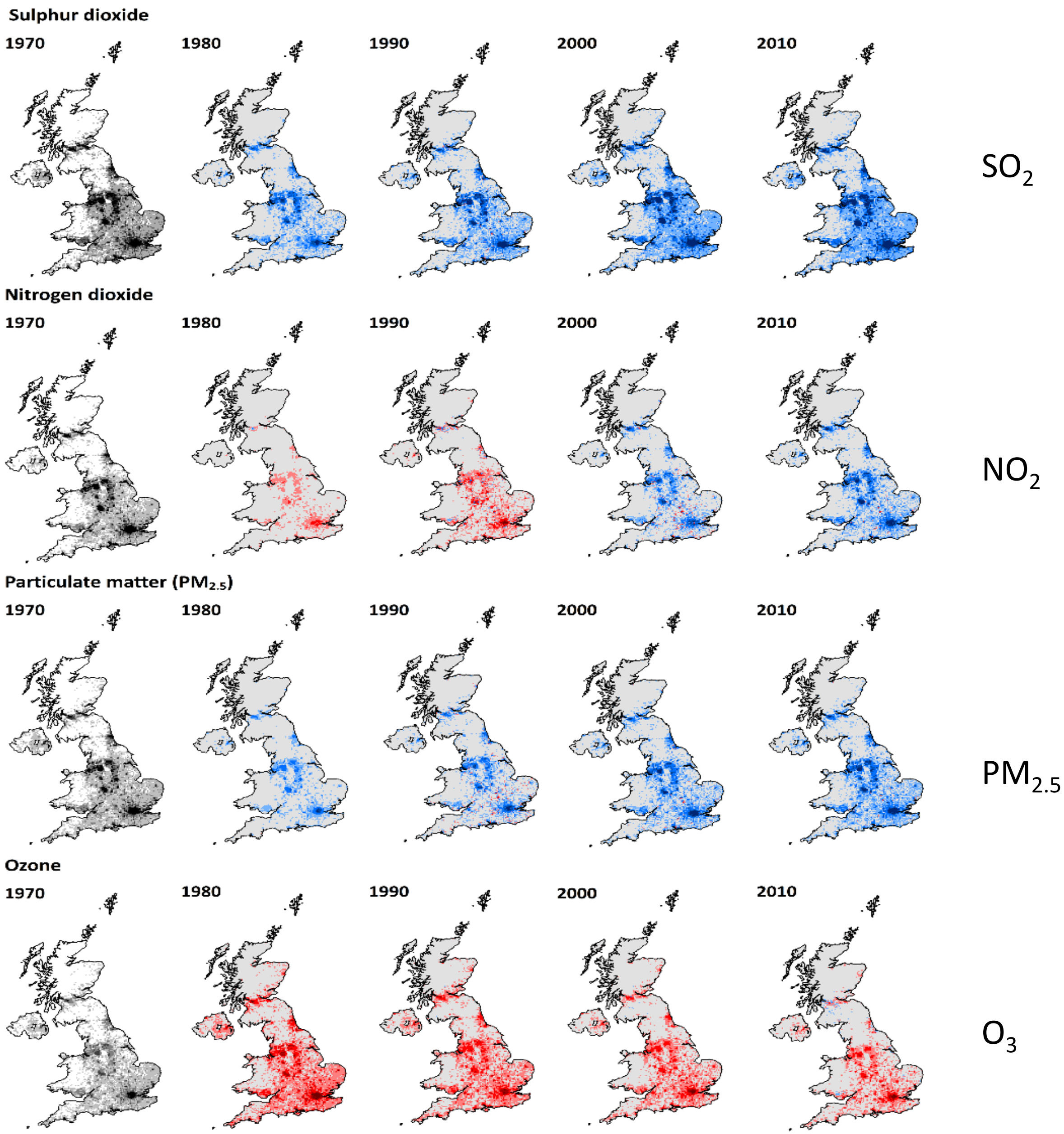


The way weather affects air pollution levels changes from day to day, year to year, influencing pollutant levels as well as changes in emissions: one consistent meteorological year used for all model runs to remove this effect.

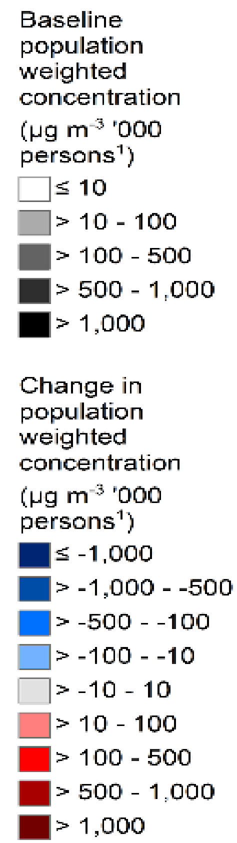
Changes in emissions used as input data to our model are the only aspect that drives concentration changes, and consequently health effects

1st and 99th confidence interval boundaries and average concentration levels shown in the figures for 10 year time steps

Changes in population weighted concentrations

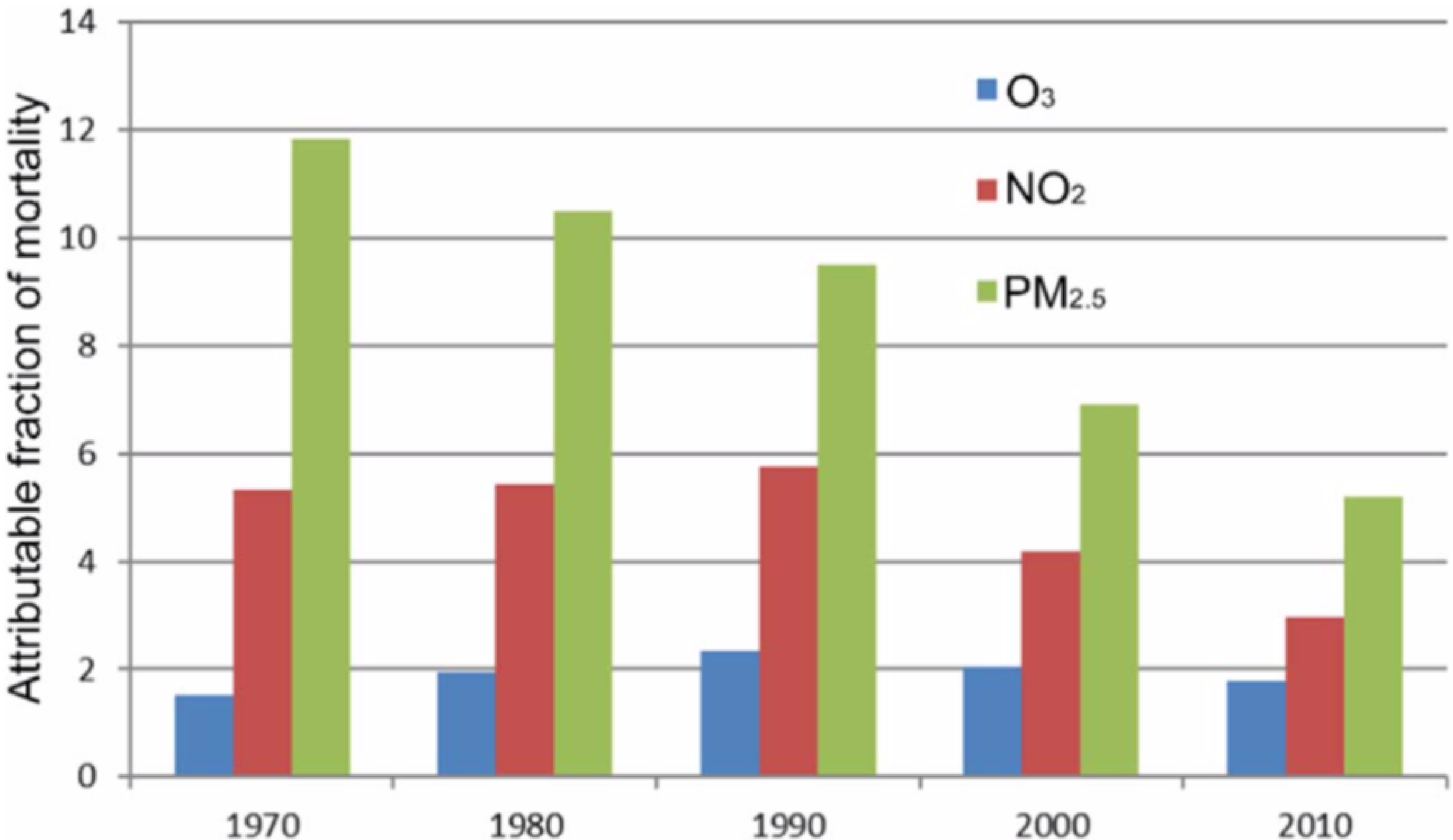


- ❑ **Blue colour** indicates decreases and **red colour** indicates increases compared to the baseline 1970.



Attributable fraction of mortality in the UK (%)

- For ozone, nitrogen dioxide and particulate matter
- 1970 to 2010



AF provides a comparative measure of health impacts related to concentrations, at different time periods, if other factors (meteorology, health status) were constant

Quantifying the health impacts from air pollution

There are lots of ways to express health impacts of air pollution (e.g. years of life lost, reduction in life expectancy…)

Air pollution does not directly cause death, rather it is a contributing factor to mortality

Many diseases are caused by multiple risk factors

Since all these pollutants are likely to contribute to mortality, and often come from similar sources, their separate effects should not be added up

Key messages of the study

Action on air pollution works but far more is needed, study shows

UK’s dirty air still ‘a public health emergency’ despite dramatic fall in death rates

theguardian.com

Summary

Air quality modelling helps to understand the effects of emissions changes over long time periods and helps to address spatial gaps in data

Policy controls (on a range of scales from UK to international) have largely helped to improve the impacts of air pollution on health since the 1970s, and can lead to further improvements in future

There are remaining challenges from local hotspots, and emerging emission sources, e.g. domestic wood burning and ammonia from agriculture

Calculation of health impacts (AF)

- AF is related to the concentration (x) of air pollutant, and coefficient (β) relating concentration to mortality:

$$AF = [(RR - 1)/RR]$$

$$\text{where RR (relative risk)} = \beta^{(x/10)}$$

Example: $PM_{2.5}$ in 2010 in the UK:

$x = 9.18\ \mu g\ m^{-3}$

$\beta = 1.06$ (approx. 6% increase in mortality per $10\mu g\ m^{-3}$ $PM_{2.5}$)

RR = 1.06^(9.18/10) = 1.055

AF = ((1.055-1) / 1.055) * 100 = **5.21 %**

Notes about the use of attributable fractions (AF)

- AF represents an estimate of the percentage of total deaths in the UK which we attribute to air pollution
- We did not calculate absolute mortality figures:
  - The coefficients relating exposure and mortality (β) are derived based on recent empirical evidence
  - Mortality rates were different in 1970, not just due to air pollution
  - We do not calculate absolute mortality attributable to air pollution because competing (confounding) factors mean the results would not be comparable
- <u>AF provides a comparative measure of health impacts related to concentrations, at different time periods, if other factors (meteorology, health status) were constant</u>