The Links Between Air Pollution and COVID-19

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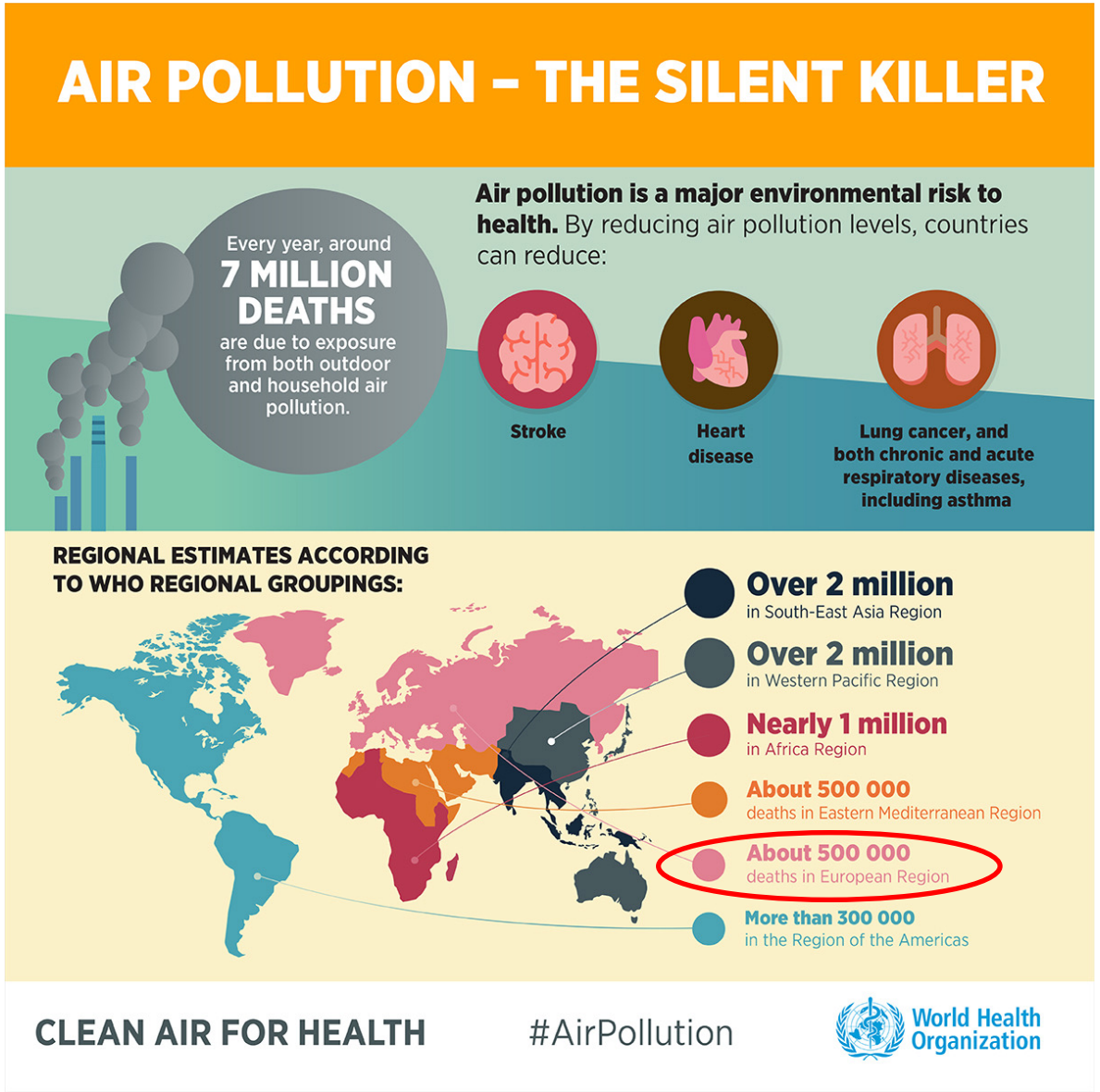
Air Pollution: The Silent and often Invisible Killer



"Air pollution is the 'new tobacco', warns WHO head."

- Source: WHO

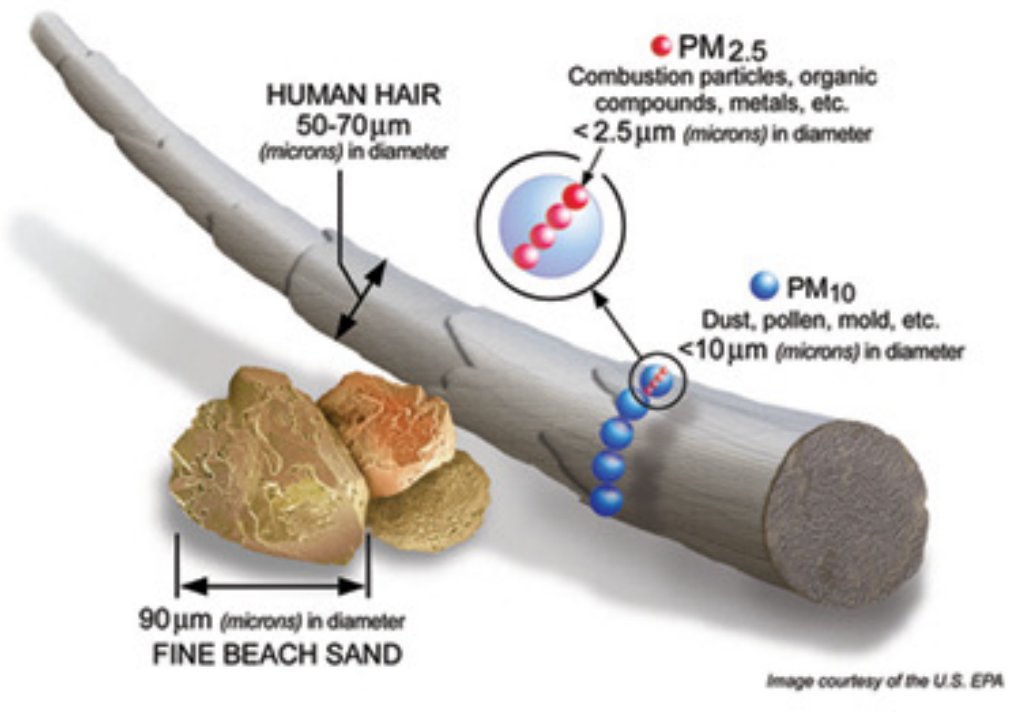
Latest EEA Report

- 41 European countries - around 440,00 premature deaths in 2019
- Ireland – over 1,300 premature deaths in 2019

Particulate Matter: The problem pollutant

PM_{10} Particulate Matter with diameter less than 10 micrometres

$PM_{2.5}$ Particulate Matter with diameter less than 2.5 micrometres



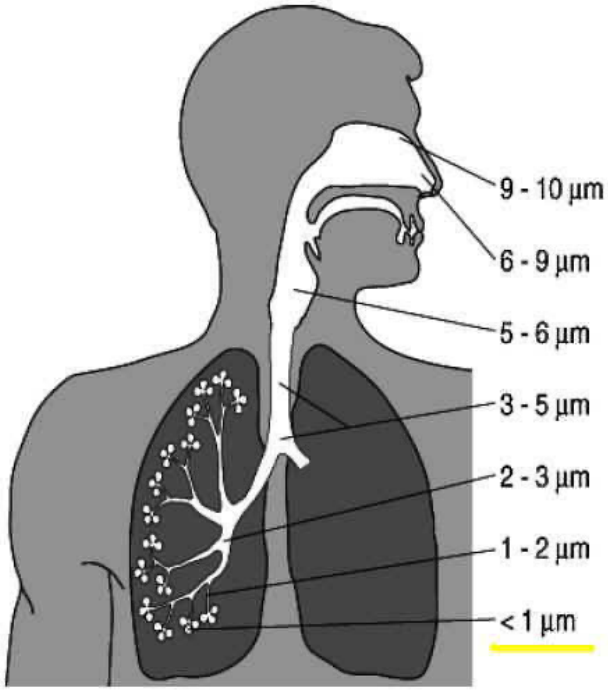


Figure 2 Particle deposition in respiratory system

PM_{10} enters upper respiratory system

$PM_{2.5}$ can penetrate deep into the lungs

Greater health risk associated with exposure to smaller particles

- Short term (hours, days) exposure: respiratory and cardiovascular morbidity, e.g. asthma
- Long term (years) exposure: death from cardiovascular and respiratory diseases, lung cancer

Latest Research

- Tiny airborne particles found in almost all major organs

Air pollution particles found in mothers' placentas

New research shows direct evidence that toxic air – already strongly linked to harm in unborn babies – travels through mothers' bodies

▲ The new study, involving mothers living in London, revealed sooty particles in their placentas. Photograph: Keith Levit/Alamy Stock Photo

The Guardian 16/09/2018

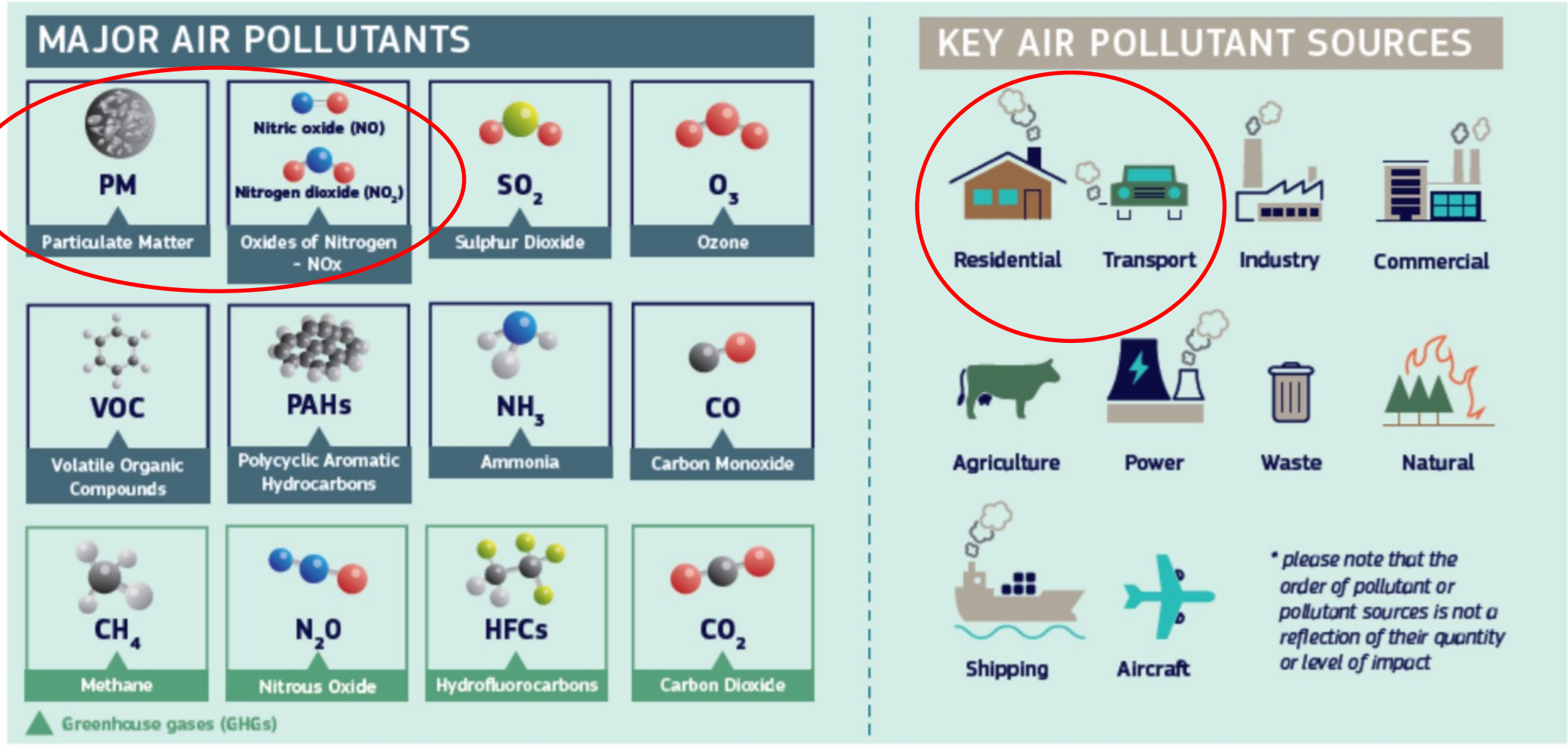
Air pollution particles in young brains linked to Alzheimer's damage

Exclusive: if discovery is confirmed it will have global implications as 90% of people breathe dirty air

The research found pollution nanoparticles in the brainstems of 186 young people between the age of 11 months and 27 years. Photograph: Nick Ansell/PA

The Guardian 06/11/2020

Main Air Pollutants and Sources

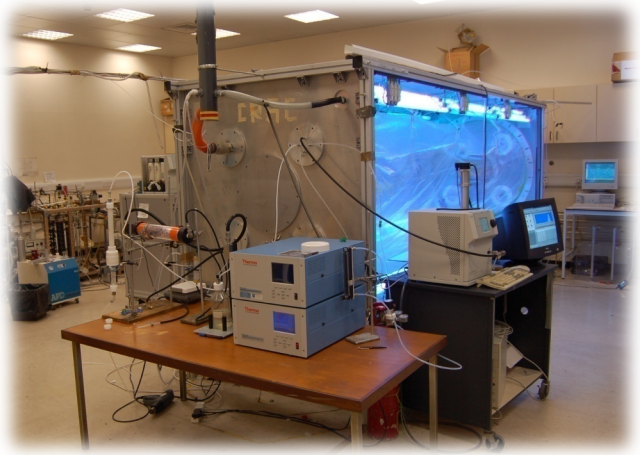


- Source: EPA/DCCAE

Centre for Research into Atmospheric Chemistry (CRAC Lab)

Mission: To improve our understanding of atmospheric composition and its influence on climate, air quality, health and the environment

Simulation Chambers

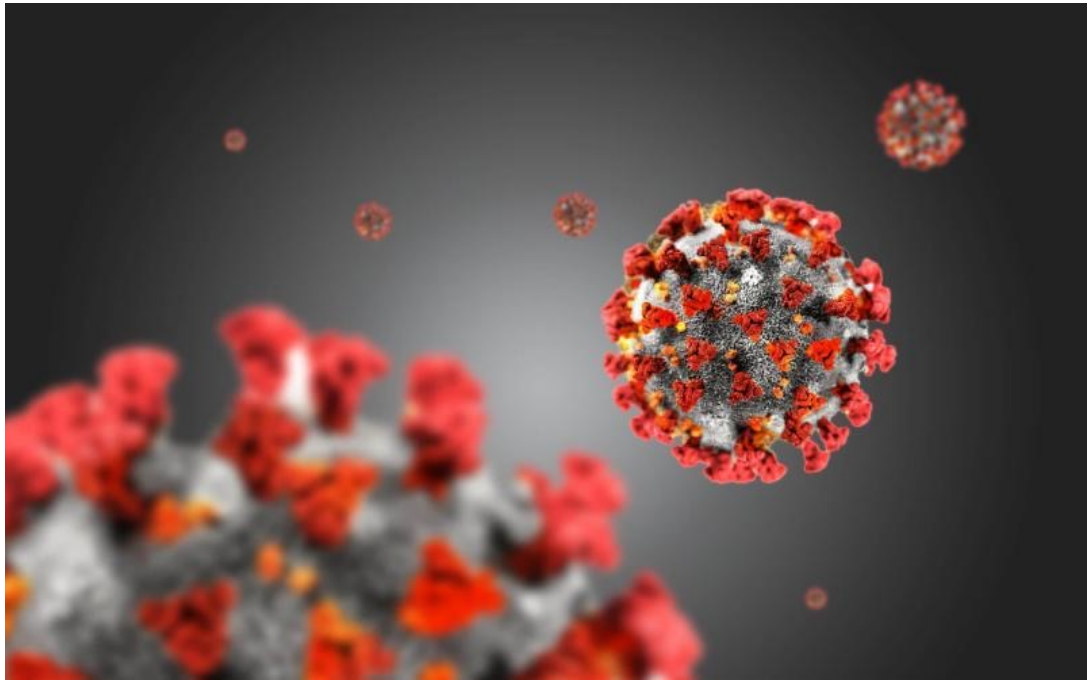


Mobile Laboratory

Monitoring Station

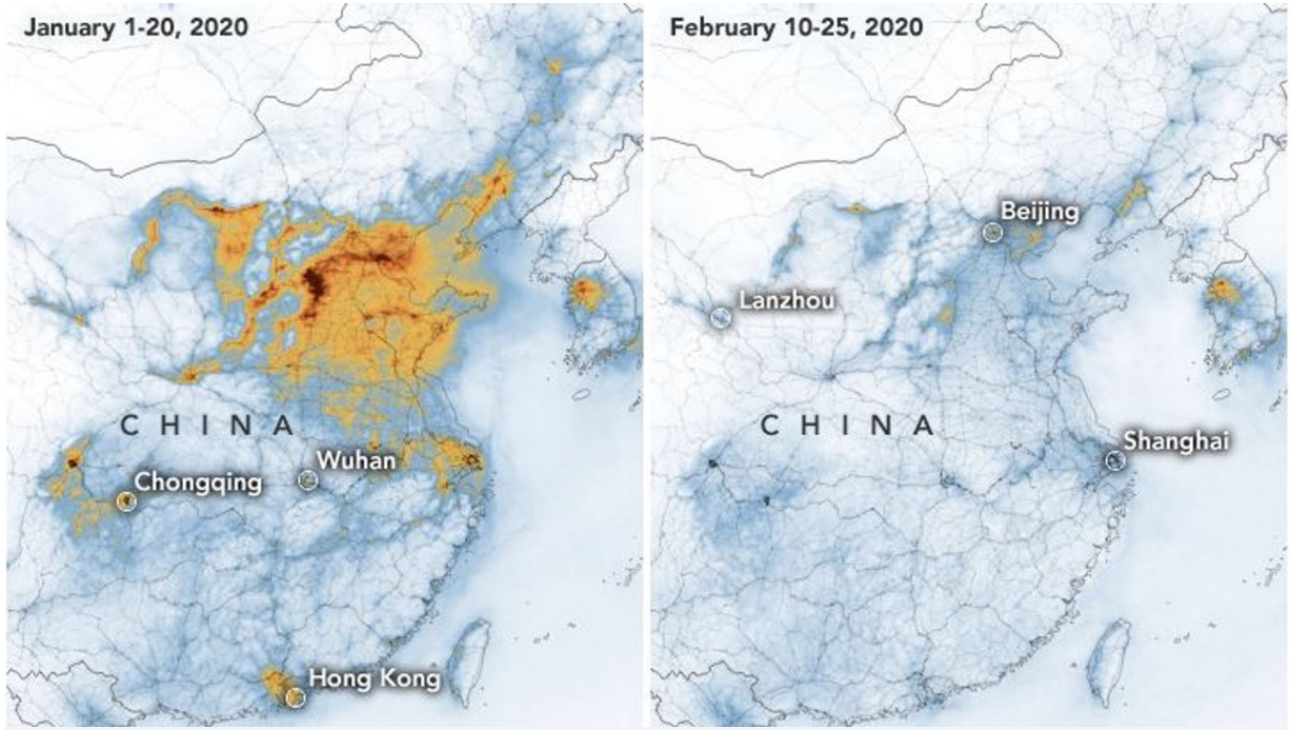
http://www.ucc.ie/en/crac

Twitter: @CRAClabUCC



1. **How did COVID-19 restrictions affect air quality?**
2. **How does air quality affect COVID-19 outcomes?**

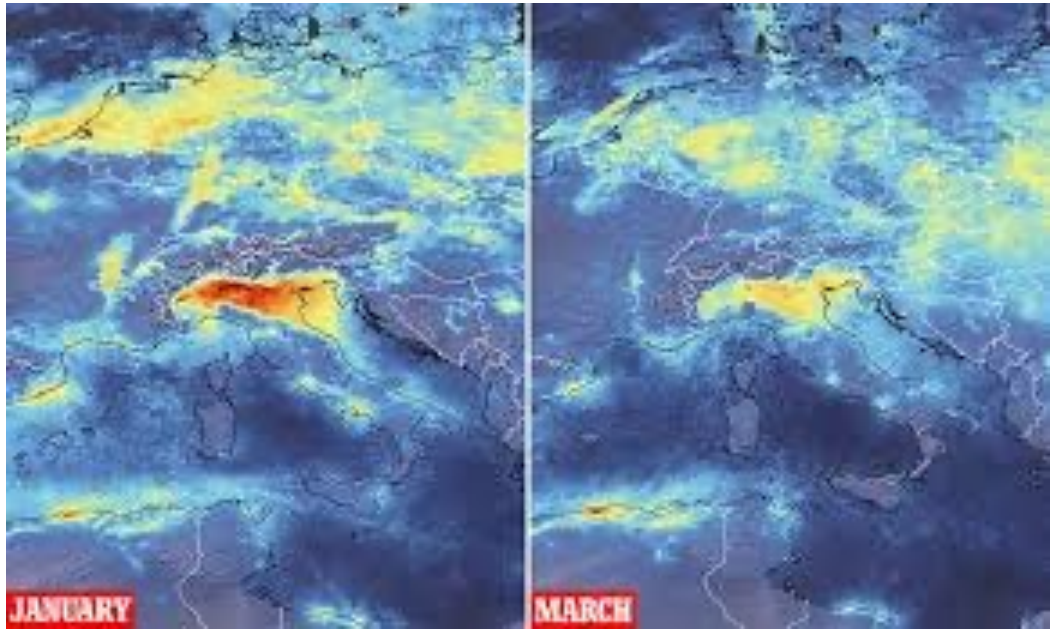
Impact of COVID-19 Restrictions on Air Quality in China and Italy



NASA says the outbreak is 'partly related' to the decline in NO2 over China. Pic: NASA

- Large reductions in NO_2 observed by satellite measurements

https://www.youtube.com/watch?time_continue=5&v=SSnMuf4h-N0&feature=emb_logo



https://www.rte.ie/news/coronavirus/2020/0320/1124295-air-pollution-is-down-will-we-take-heed-of-lessons/

Impact of COVID-19 Restrictions on Air Quality in India

Delhi's air quality has improved remarkably during the shutdown

People in India can see the Himalayas for the first time in 'decades,' as the lockdown eases air pollution

Rob Picheta, CNN • Updated 9th April 2020

- Large reductions in $PM_{2.5}$ significantly improve visibility

The Himalayas stand clear to view from Pathankot, in the Punjab. The coronavirus lockdown has rapidly reduced pollution
@PARASRISHI

https://www.bbc.com/news/world-asia-india-52313972

Impact of COVID-19 Restrictions on Air Quality in Ireland

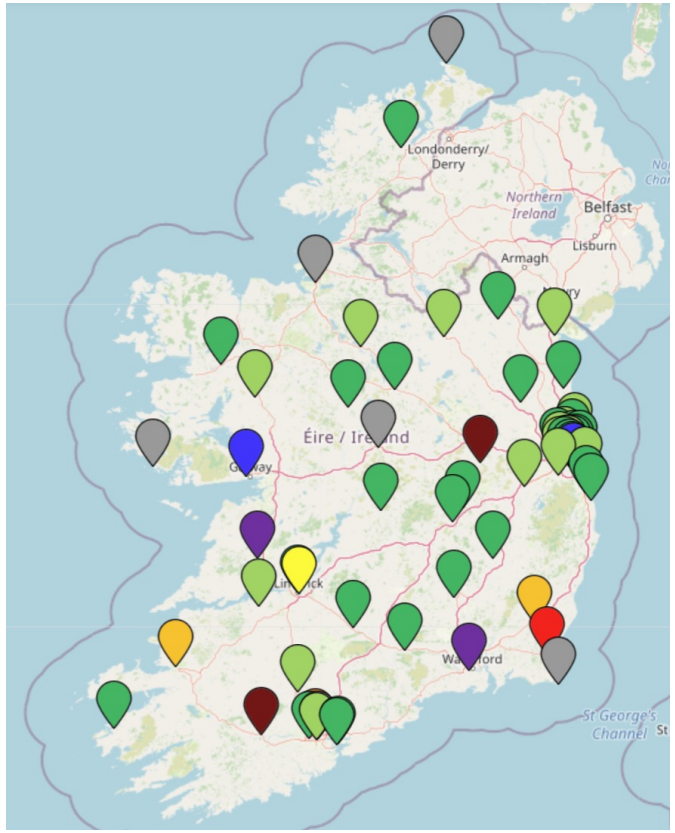
What can we expect during restrictions?

- NO_2:
  - 🚗 Less traffic => less NO_2 emissions => *better* air quality

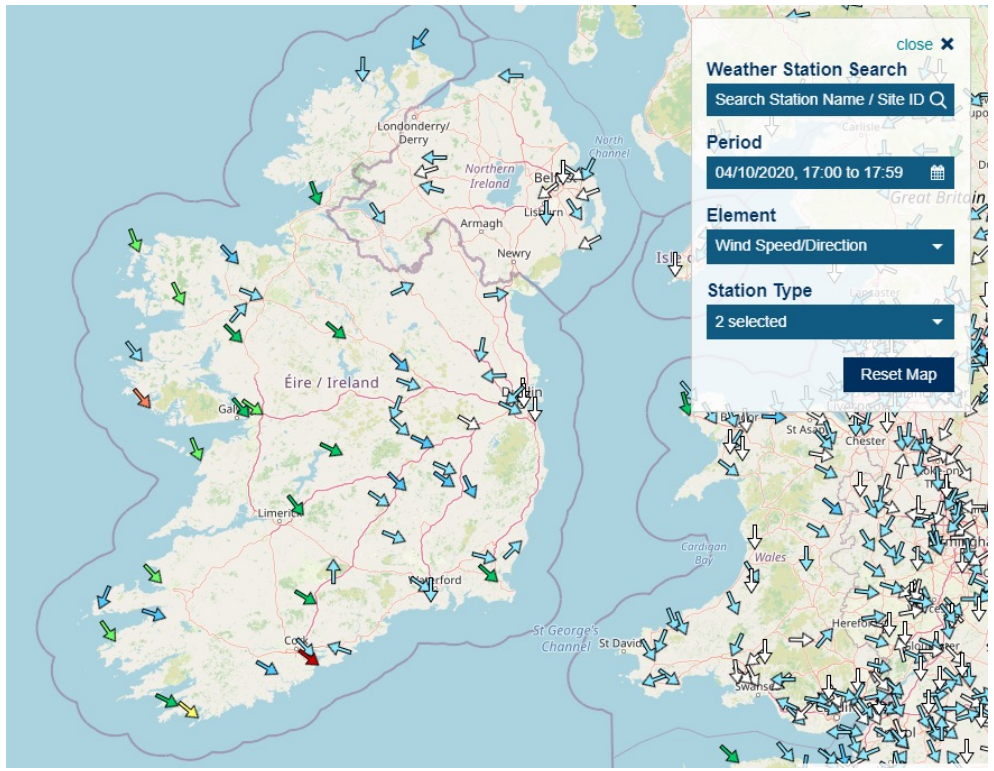
- $PM_{2.5}$:
  - 🚗 Less traffic => less $PM_{2.5}$ emissions => *better* air quality
  - 🔥 More time spent indoors => more residential heating emissions => *worse* air quality

Impact of COVID-19 on Air Quality in Ireland

What data can we make use of?



National AQ Monitoring Network



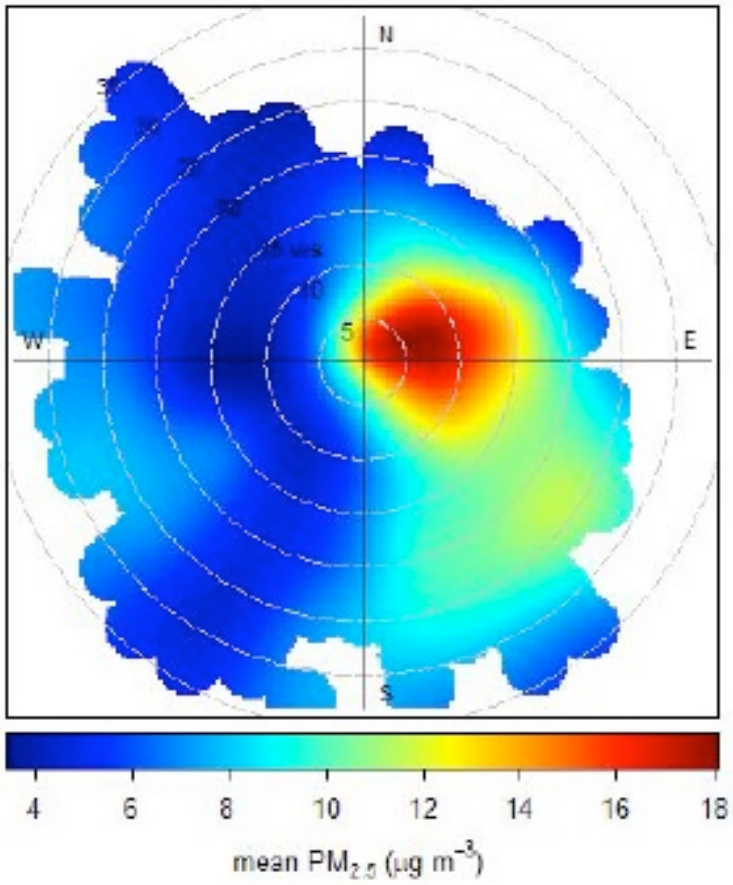
Meteorological observations

Meteorological Normalisation of Air Quality

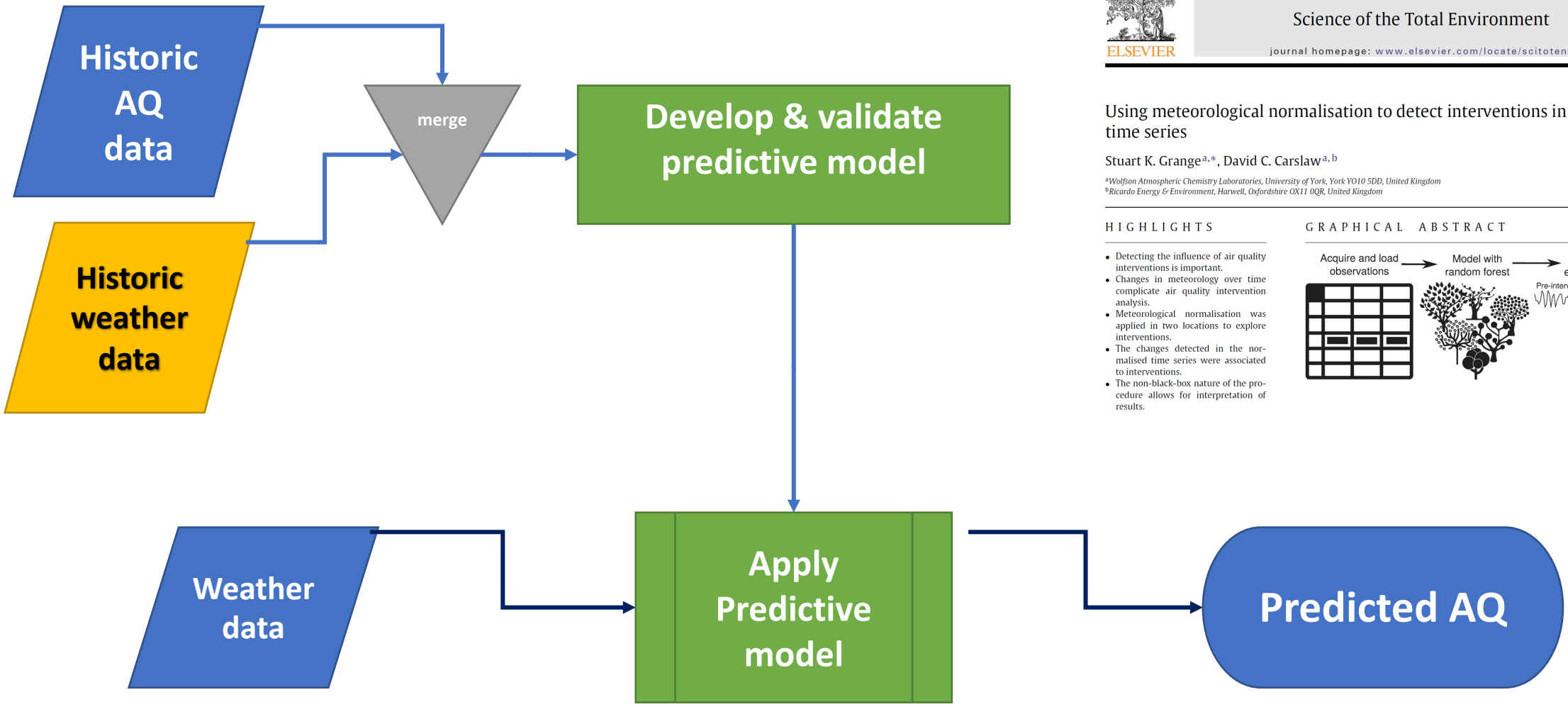
- Emissions are typically regular and predictable
- Removal processes depend on the weather
- Some emissions depend on the weather, e.g. residential heating

➢ In a given location, the main reason for variation in pollution levels is the weather (local and synoptic)

  ➢ Unusual changes in emissions can be observed as model deviations from measured levels



Meteorological Normalisation of Air Quality



Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Using meteorological normalisation to detect interventions in air quality time series

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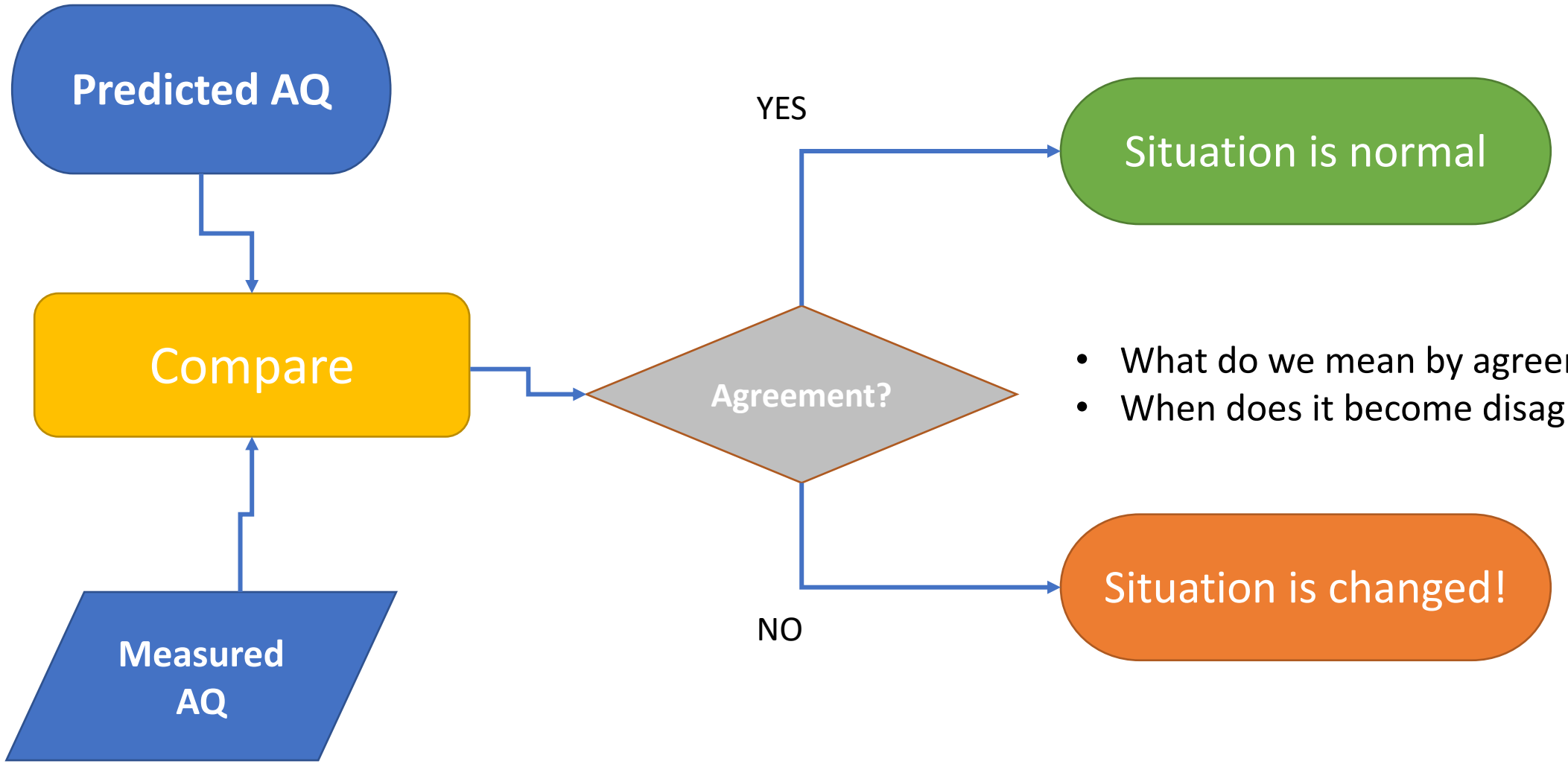
[b]Ricardo Energy & Environment, Harwell, Oxfordshire OX11 0QR, United Kingdom

HIGHLIGHTS

- Detecting the influence of air quality interventions is important.
- Changes in meteorology over time complicate air quality intervention analysis.
- Meteorological normalisation was applied in two locations to explore interventions.
- The changes detected in the normalised time series were associated to interventions.
- The non-black-box nature of the procedure allows for interpretation of results.

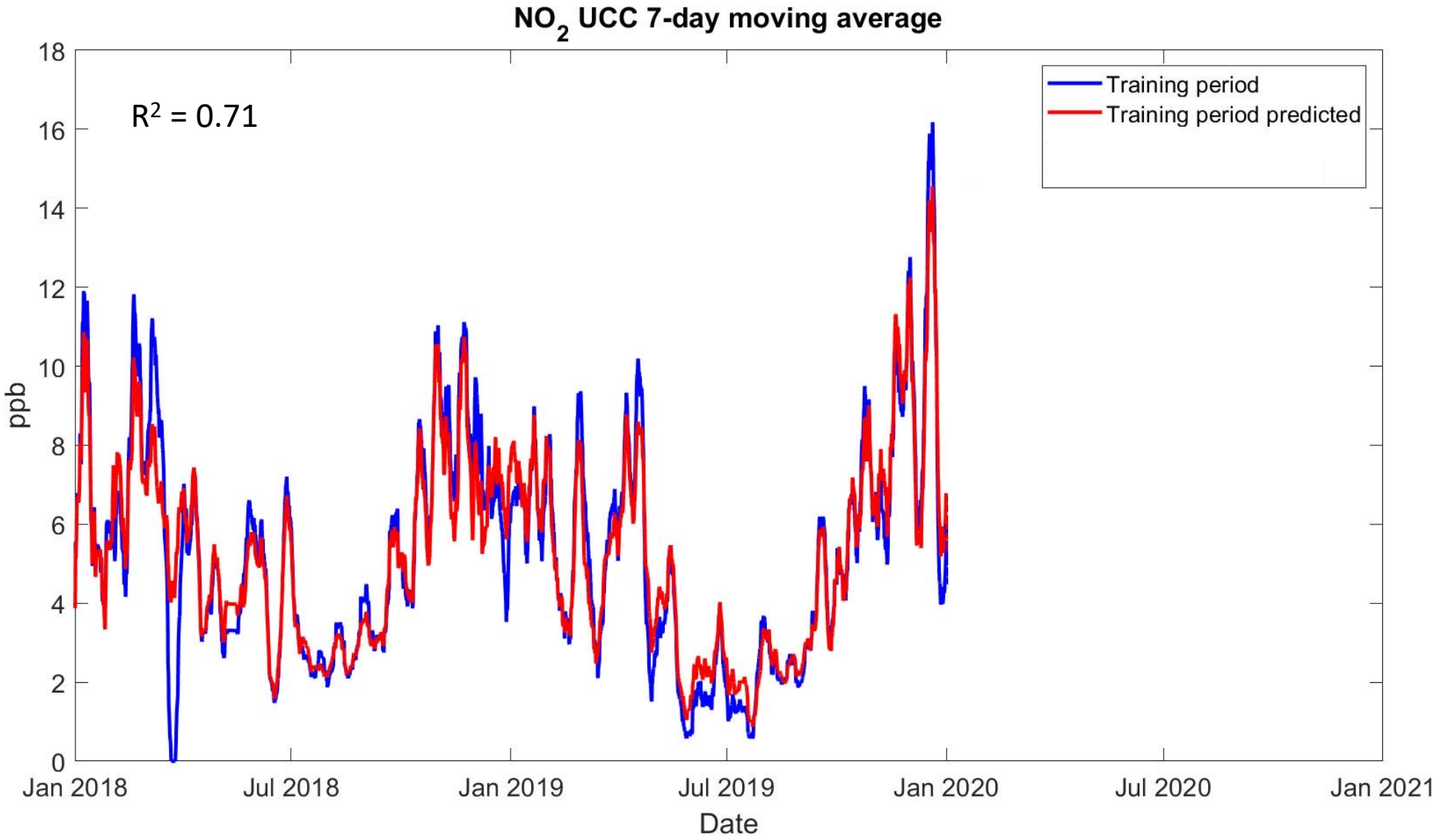
GRAPHICAL ABSTRACT

Meteorological Normalisation of Air Quality

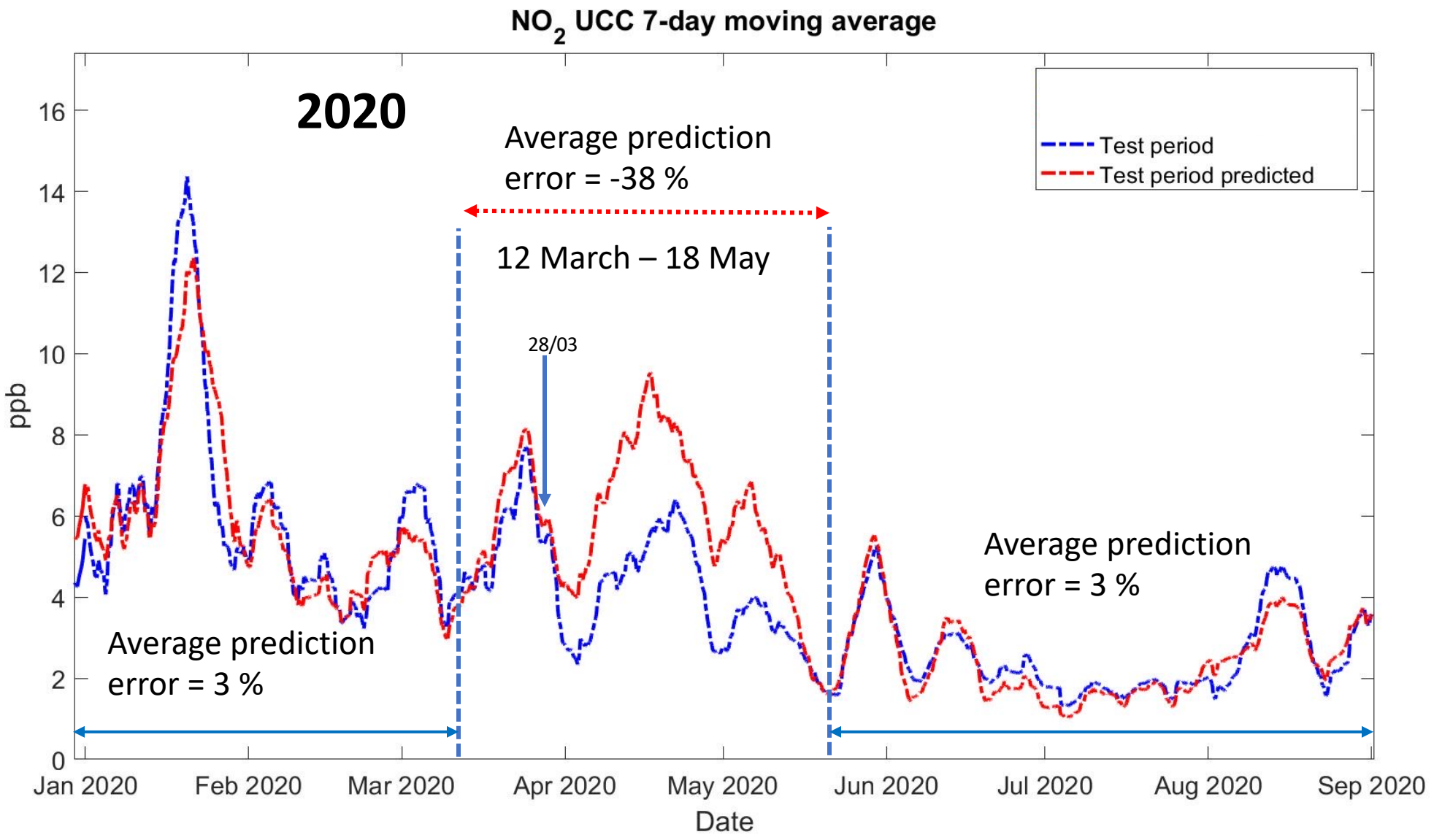


- What do we mean by agreement?
- When does it become disagreement?

Model Training Period: NO_2

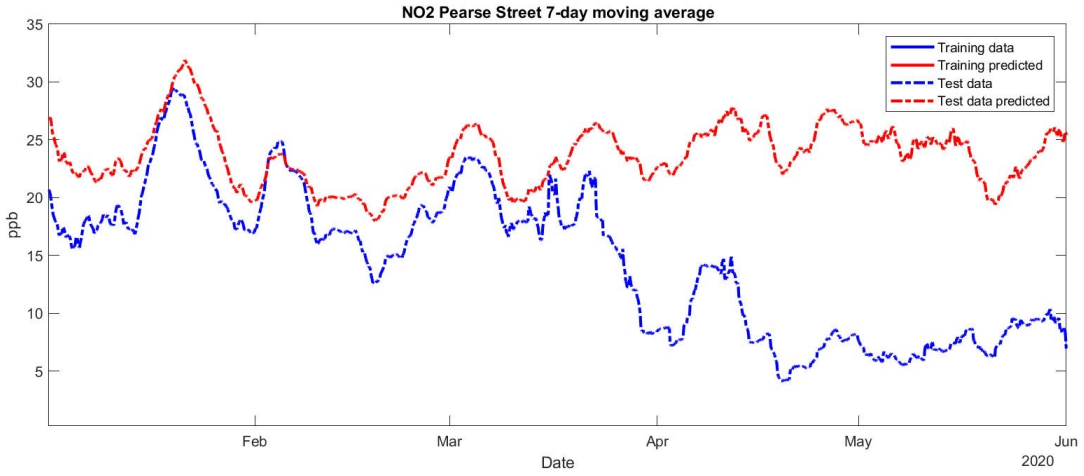


Model Test Period: NO_2

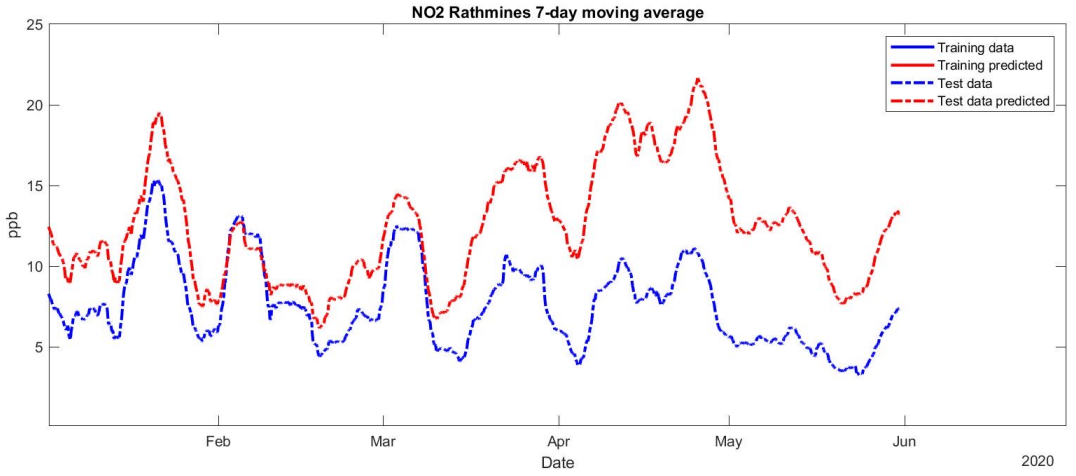


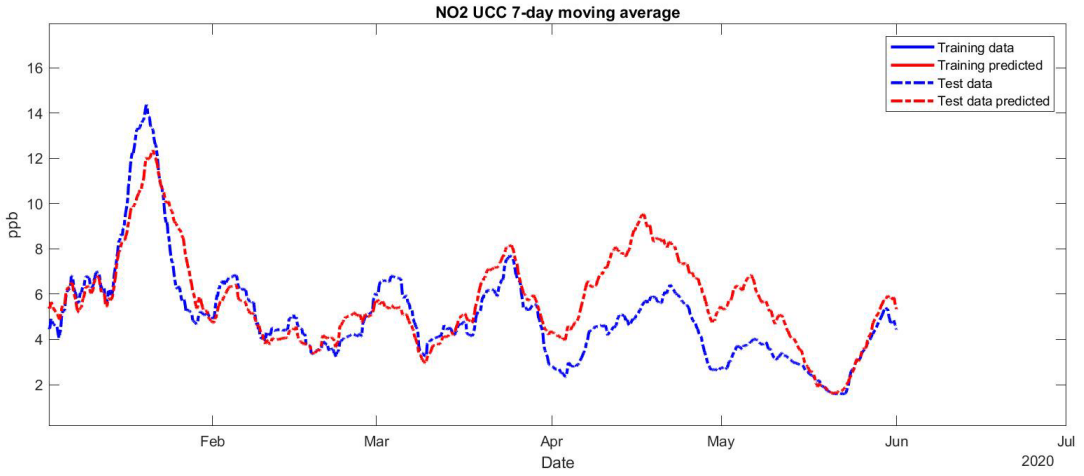
Predicted v Measured NO_2

Dublin Pearse St (57% reduction)



Dublin Rathmines (48% reduction)

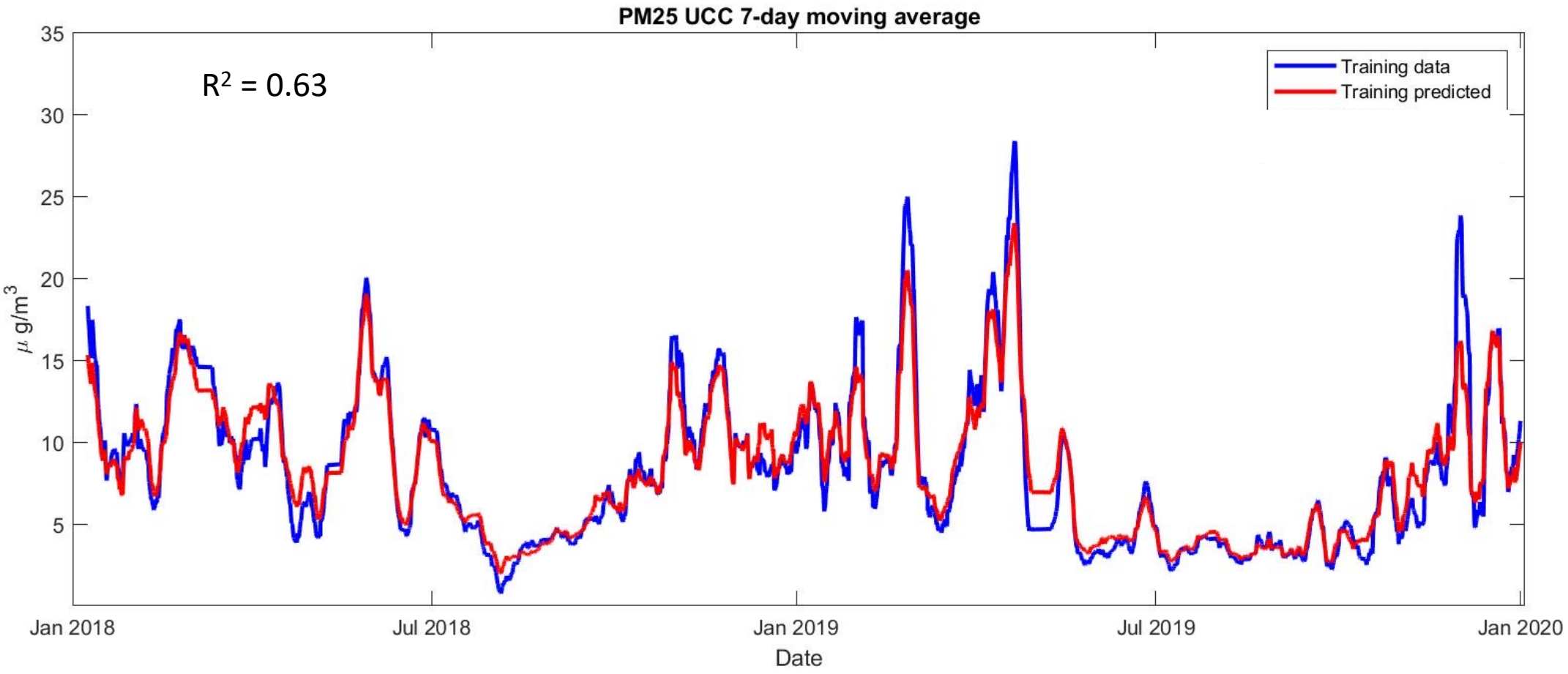




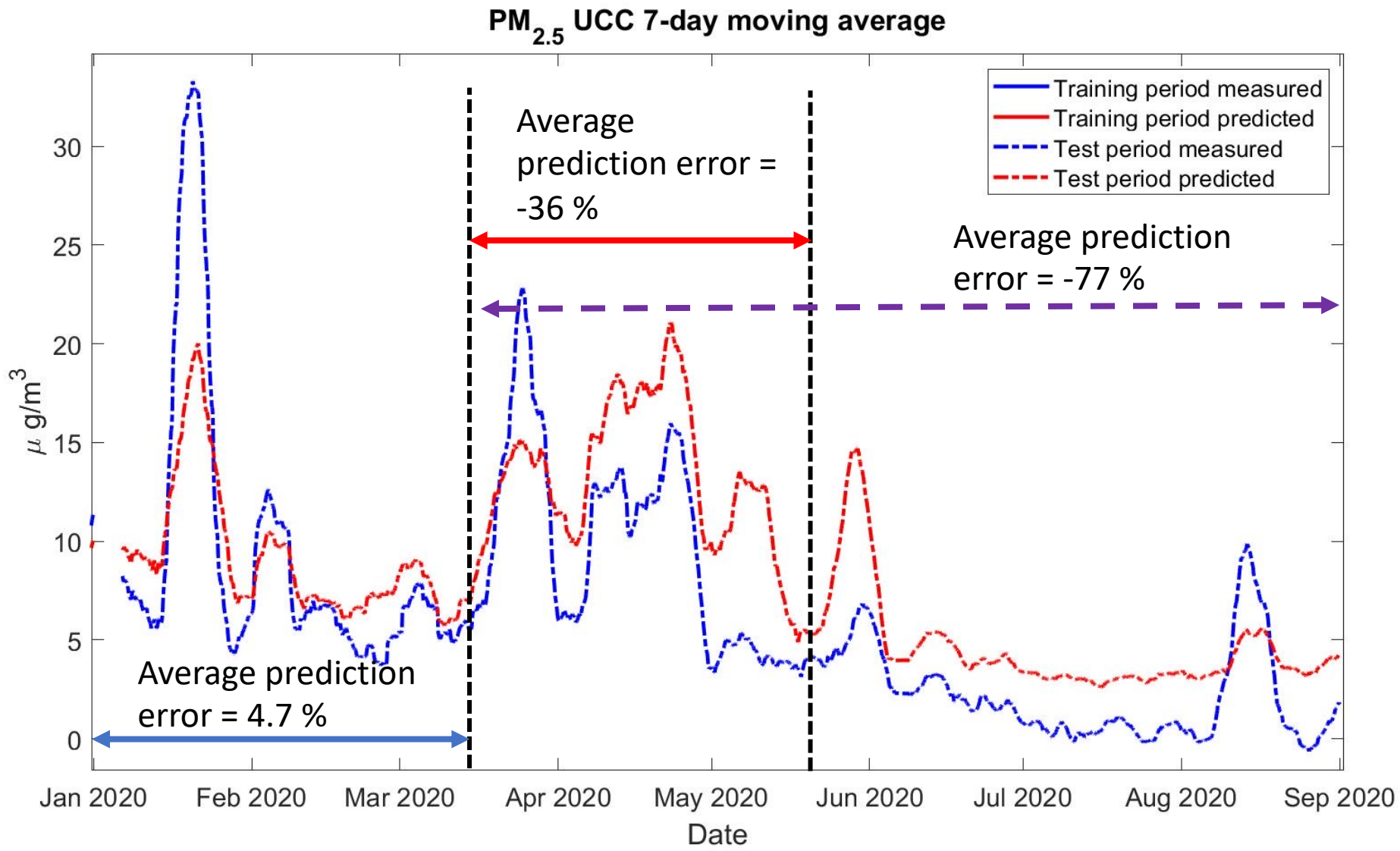
Cork UCC (27% reduction)

- Reductions observed at all urban sites
- Largest reductions at roadside locations
- After easing of restrictions:
  - Pollutant levels remained below expected levels at some sites
  - Return to business as usual for others, e.g. UCC, Finglas, Phoenix Park

Model Training Period: $PM_{2.5}$

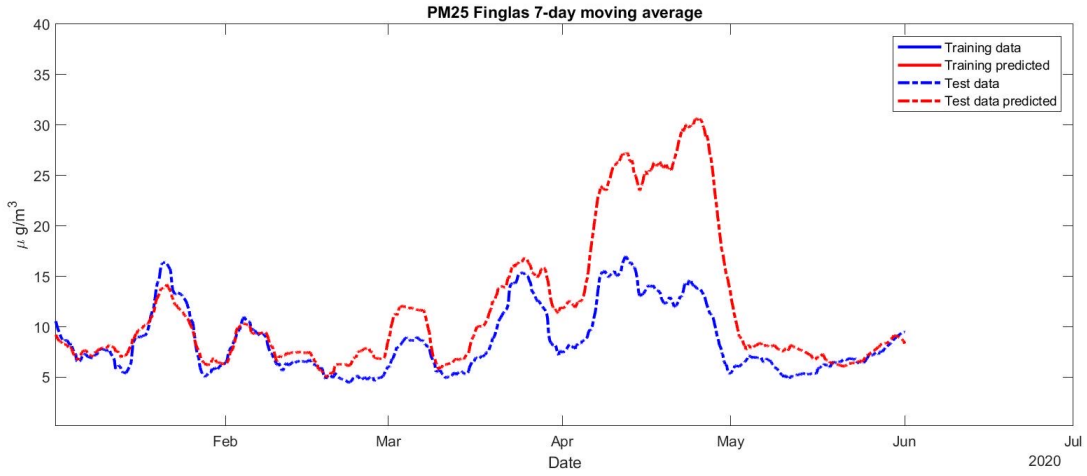


Model Test Period: $PM_{2.5}$

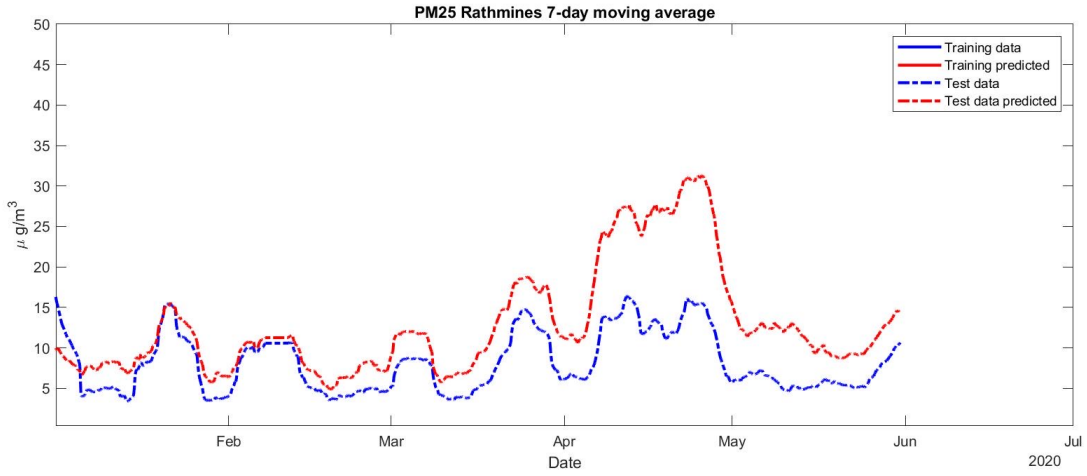


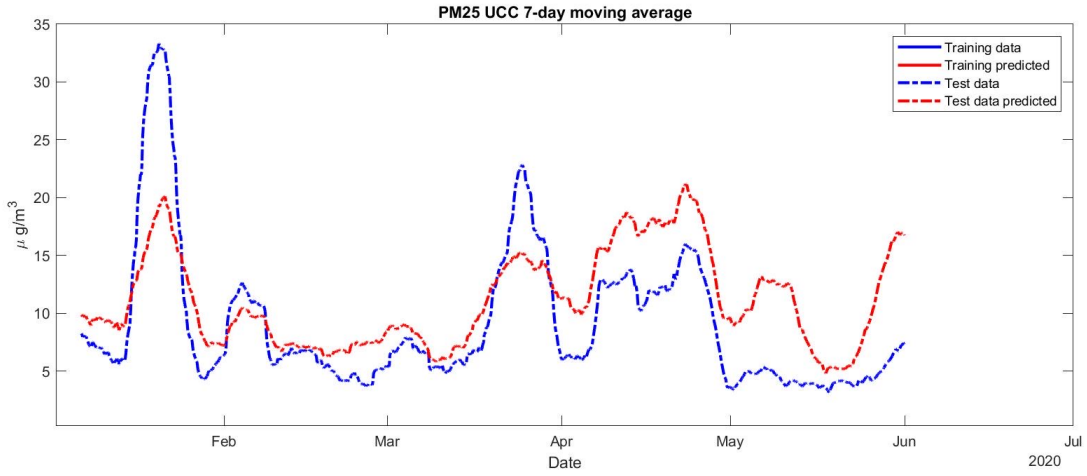
Predicted v Measured $PM_{2.5}$

Finglas (36% reduction)



Dublin Rathmines (47% reduction)



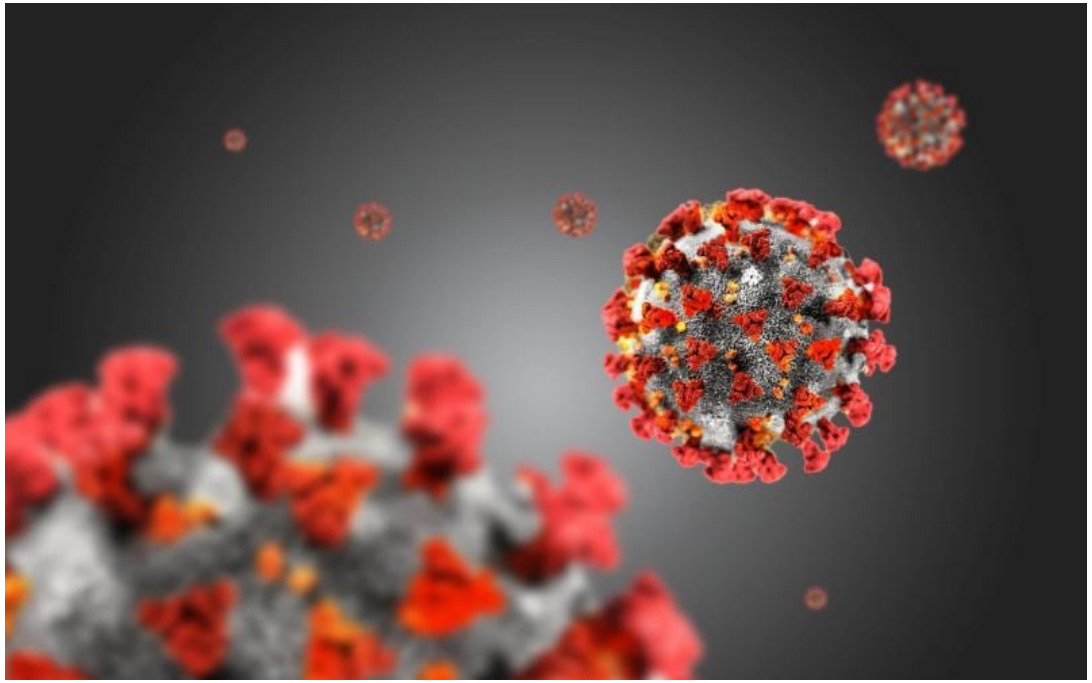


Cork UCC (29% reduction)

- Reductions observed at all urban sites
- Largest reductions at roadside locations
- After easing of restrictions:
  - Pollutant levels remained below expected levels at some sites
  - Return to business as usual for others, e.g. Finglas, Phoenix Park

Summary 1

- COVID-19 restrictions led to reductions of 27-57% for NO_2 levels at urban sites in Dublin and Cork
- Similar reductions in $PM_{2.5}$ (20-47%) were observed at urban locations, although in some cases, this was surprising and needs further investigation
- The model predictions have proven to be a useful tool in understanding factors controlling air pollution and have great potential for determining the impact of interventions, e.g. travel restrictions.



Coronavirus
COVID-19

How does air quality affect COVID-19 outcomes?

How does air quality affect COVID-19 outcomes?

- Exposure to $PM_{2.5}$ causes inflammation and damage to the lining of the lungs over time, weakening the body's ability to fend off respiratory infections.
- It is reasonable to expect that people exposed to higher levels of pollution will be more susceptible to COVID-19 and also have more severe symptoms

SCIENCE ADVANCES | RESEARCH ARTICLE

CORONAVIRUS

Air pollution and COVID-19 mortality in the United States: Strengths and limitations of an ecological regression analysis

X. Wu[1]*, R. C. Nethery[1]*, M. B. Sabath[1], D. Braun[1,2], F. Dominici[1†]

Assessing whether long-term exposure to air pollution increases the severity of COVID-19 health outcomes, including death, is an important public health objective. Limitations in COVID-19 data availability and quality remain obstacles to conducting conclusive studies on this topic. At present, publicly available COVID-19 outcome data for representative populations are available only as area-level counts. Therefore, studies of long-term exposure to air pollution and COVID-19 outcomes using these data must use an ecological regression analysis, which precludes controlling for individual-level COVID-19 risk factors. We describe these challenges in the context of one of the first preliminary investigations of this question in the United States, where we found that higher historical $PM_{2.5}$ exposures are positively associated with higher county-level COVID-19 mortality rates after accounting for many area-level confounders. Motivated by this study, we lay the groundwork for future research on this important topic, describe the challenges, and outline promising directions and opportunities.

- Analysis of COVID-19 deaths and historic $PM_{2.5}$ data (2000-2016) in USA
- An increase of only 1 $\mu g/m^3$ in $PM_{2.5}$ is associated with an 11% increase in the COVID-19 death rate

How does air quality affect COVID-19 outcomes?

Environmental Pollution 268 (2021) 115859

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Links between air pollution and COVID-19 in England☆

Marco Travaglio [1], Yizhou Yu [1], Rebeka Popovic, Liza Selley, Nuno Santos Leal, Luis Miguel Martins*

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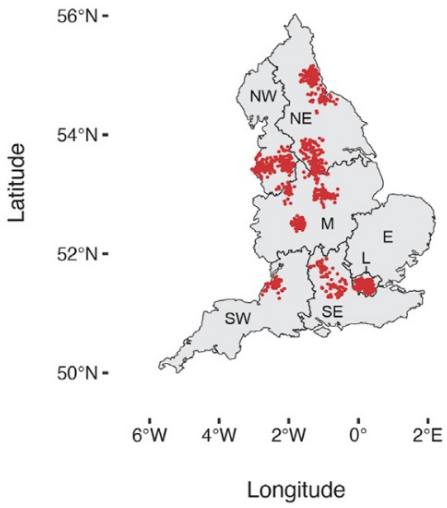
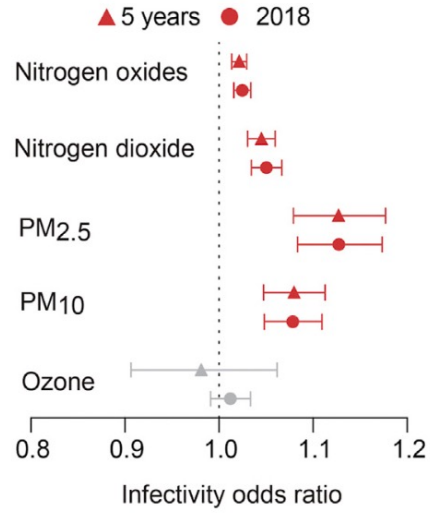
ABSTRACT

In December 2019, a novel disease, coronavirus disease 19 (COVID-19), emerged in Wuhan, People's Republic of China. COVID-19 is caused by a novel coronavirus (SARS-CoV-2) presumed to have jumped species from another mammal to humans. This virus has caused a rapidly spreading global pandemic. To date, over 300,000 cases of COVID-19 have been reported in England and over 40,000 patients have died. While progress has been achieved in managing this disease, the factors in addition to age that affect the severity and mortality of COVID-19 have not been clearly identified. Recent studies of COVID-19 in





- Positive relationships between concentrations of both nitrogen oxides and PM with COVID-19 infectivity and mortality in England
- An increase of 1 $\mu g/m^3$ in the long-term average of $PM_{2.5}$ was associated with a 12% increase in COVID-19 cases

How does air quality affect COVID-19 outcomes?

Original research

Long-term exposure to air pollution and COVID-19 incidence: a prospective study of residents in the city of Varese, Northern Italy

Giovanni Veronesi [1], Sara De Matteis [2,3], Giuseppe Calori,[4] Nicola Pepe,[4] Marco M Ferrario [1]

► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/oemed-2021-107833).

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[3]National Heart and Lung Institute, Imperial College London, London, UK
[4]Arianet S.R.L, Milano, Italy

Correspondence to
Professor Giovanni Veronesi, Research Center in Epidemiology and Preventive Medicine, Department of Medicine and Surgery, University of Insubria, Varese 21100, Italy; giovanni.veronesi@uninsubria.it

ABSTRACT

Objectives To investigate the association between long-term exposure to airborne pollutants and the incidence of SARS-CoV-2 up to March 2021 in a prospective study of residents in Varese city.

Methods Citizens of Varese aged ≥18 years as of 31 December 2019 were linked by residential address to 2018 average annual exposure to outdoor concentrations of $PM_{2.5}$, PM_{10}, NO_2, NO and ozone modelled using the Flexible Air quality Regional Model (FARM) chemical transport model. Citizens were further linked to regional datasets for COVID-19 case ascertainment (positive nasopharyngeal swab specimens) and to define age, sex, living in a residential care home, population density and comorbidities. We estimated rate ratios and additional numbers of cases per 1 µg/m^3 increase in air pollutants from single- and bi-pollutant Poisson regression models.

Results The 62 848 residents generated 4408 cases. Yearly average $PM_{2.5}$ exposure was 12.5 µg/m^3. Age, living in a residential care home, history of stroke and medications for diabetes, hypertension and obstructive airway diseases were independently associated with COVID-19. In single-pollutant multivariate models,

Key messages

What is already known about this subject?
- Although ecological studies found a correlation between air pollution and COVID-19, associations should be confirmed in prospective studies with individual-level data on airborne pollutant exposure, COVID-19 and comorbidities.

What are the new findings?
- In our prospective study of adult residents in the city of Varese in northern Italy we found that an increase of 1 µg/m^3 in the annual average exposure to $PM_{2.5}$ was associated with a 5.1% increase in the rate of COVID-19 independently of covariates, corresponding to 294 additional cases per 100 000 person-years.
- The association was confirmed by a number of sensitivity analyses, including bi-pollutant models, seasonal versus annual average exposure, pandemic period and after excluding individuals living in residential homes.

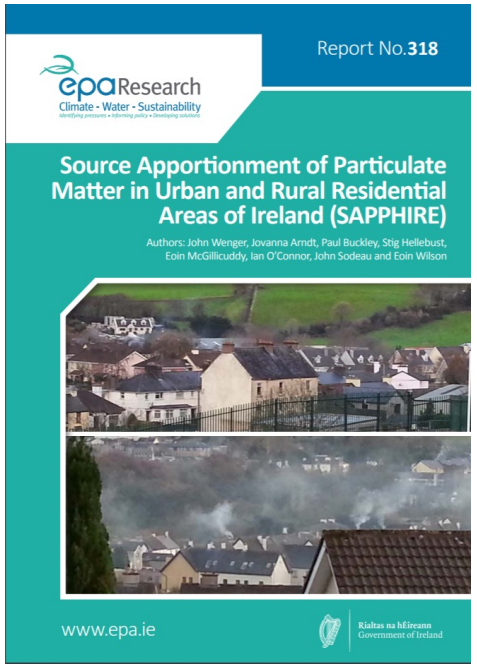
- An increase of 1 μg/m^3 in the annual average of $PM_{2.5}$ was associated with a 5.1% increase in COVID-19 cases in Varese

Summary 2

- A small increase in long term exposure to air pollution leads to a significant increase in COVID-19 infectivity and mortality
- Reductions in $PM_{2.5}$ will provide the strongest benefits for public health
- Main sources are solid fuel burning (winter), traffic (year round) and agriculture (seasonal)
- Reduced emission from these sectors represent a win-win scenario for air quality, health and climate

- Rapid introduction of measures to reduce solid fuel burning will support the nationwide effort in tackling COVID-19

http://www.epa.ie/researchandeducation/research/researchpublications/researchreports/research318.html



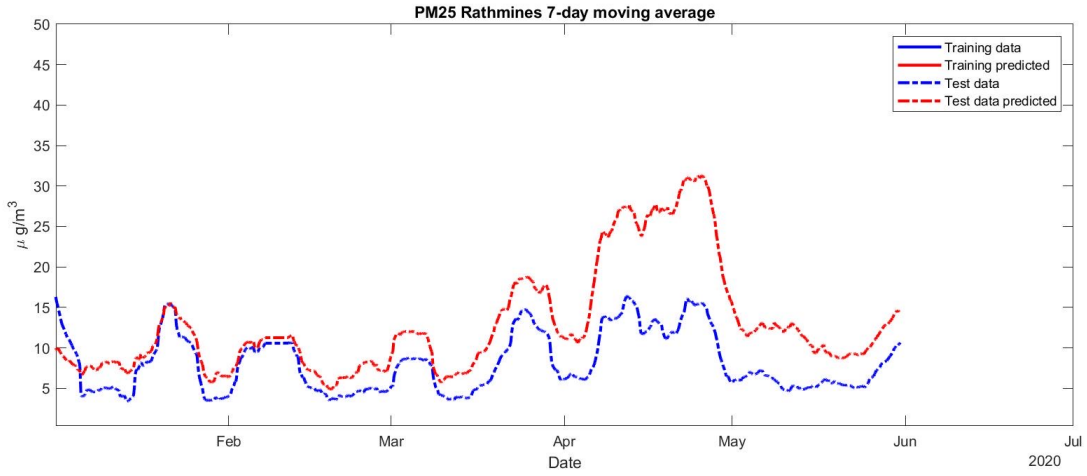
Acknowledgements

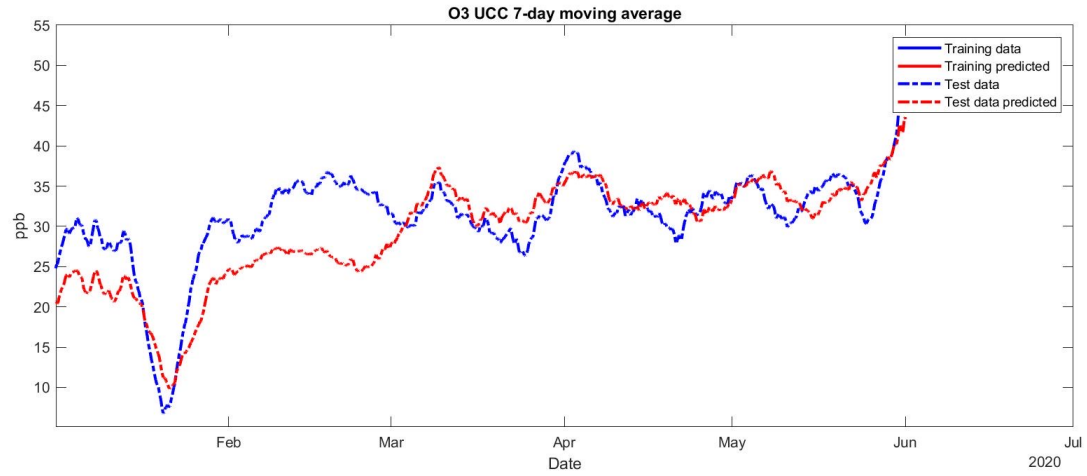
- CRAC Lab colleagues, Rósín Byrne, Niall O'Sullivan and especially Stig Hellebust for data analysis and preparation of the graphs

- EPA Air quality team for data provision

Predicted v Measured O_3

Dublin Rathmines (8% increase)





Cork UCC (2% reduction)

- Most sites show no real difference from the predicted value
- Increase in ozone observed at two roadside locations in Dublin (Pearse St., Rathmines) due to reduced emissions of NO from road vehicles

Modelling and meteorological normalisation

- A model is developed using historic air quality and meteorological data - used to explain and predict measured levels of air pollutants on the basis of weather and temporal cycles.
- Air Quality data from sites across Ireland provided by EPA Air Quality Team
- Meteorological parameters used to predict measured concentrations are:

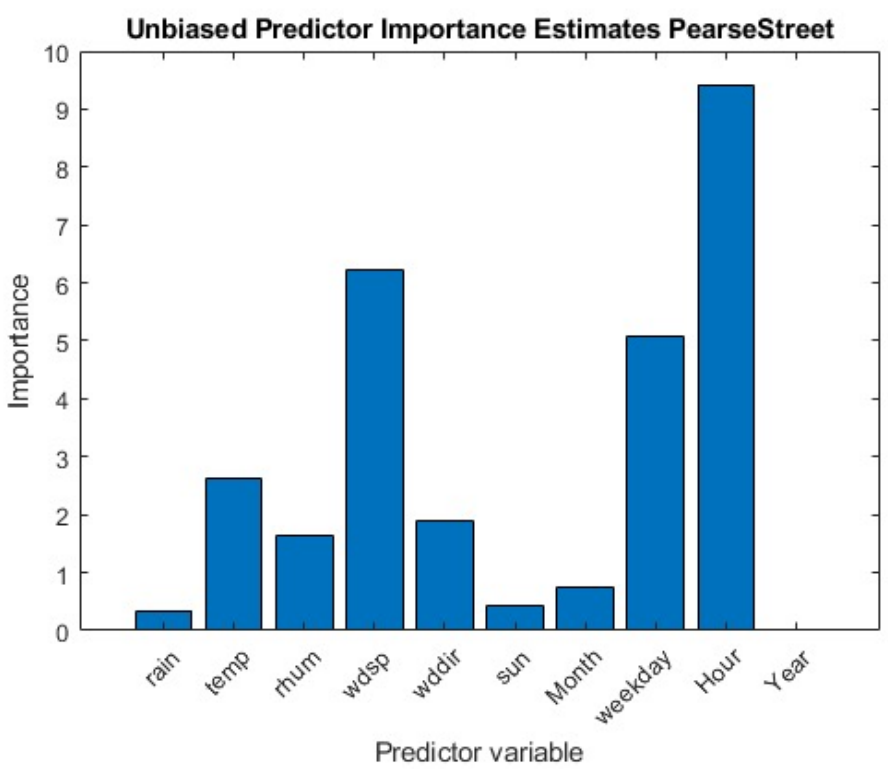
  wind speed, wind direction, rain, temperature, relative humidity, sunlight hours

  In addition, the following parameters are included:

  Hour of the day, day of the week, month and year
- Used a random forest model with an ensemble of 300 regression trees and out-of-bag sampling
- Model predictions validated against the training set (data up till end of 2019)
- Predicted concentrations of pollutants compared to measured values to quantify the impact of COVID-19 restrictions

Factors influencing the Model Predictions

Dublin city roadside (Pearse Street): wind speed, weekday and time of day



Cork Urban background (UCC): wind, time of day, season, temperature