The links between air pollution and COVID-19

Presenter: Professor John Wenger, Director of the Centre for Research into Atmospheric Chemistry, Environmental Research Institute and School of Chemistry, UCC

Moderator: Professor Astrid Wingler, Professor of Plant Biology, Head of Plant Science, School of Biological, Earth and Environmental Sciences, University College Cork

Welcome, we will begin shortly…

During the presentation you will be on mute,
so please type your Qs into the Q&A text box,
or vote (via 'thumbs up') for Qs which echo
your own.

The Links Between Air Pollution and COVID-19

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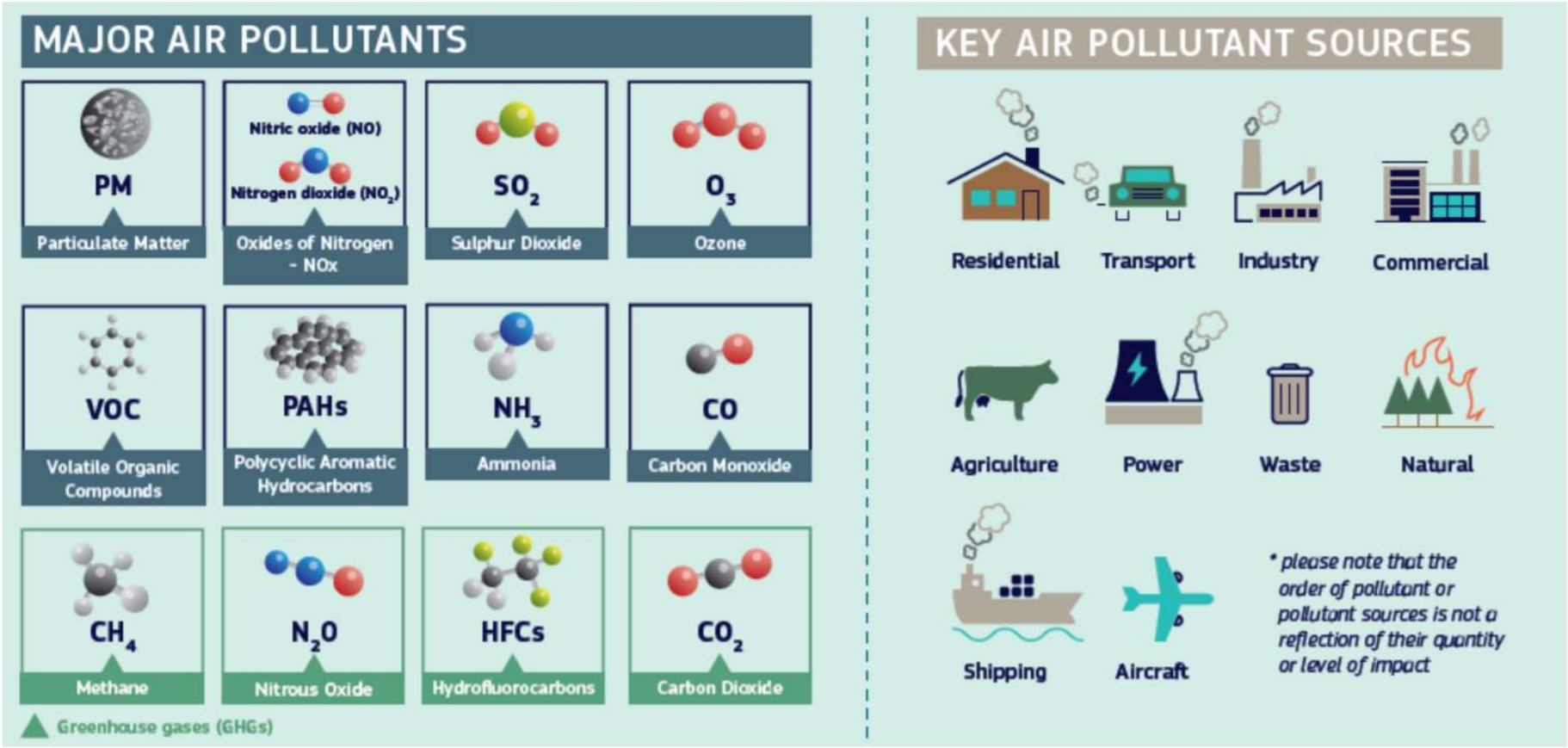
Twitter: @johnwenger and @CRAClabUCC

Air Pollution: The Silent and often Invisible Killer

- Source: WHO

Main Air Pollutants

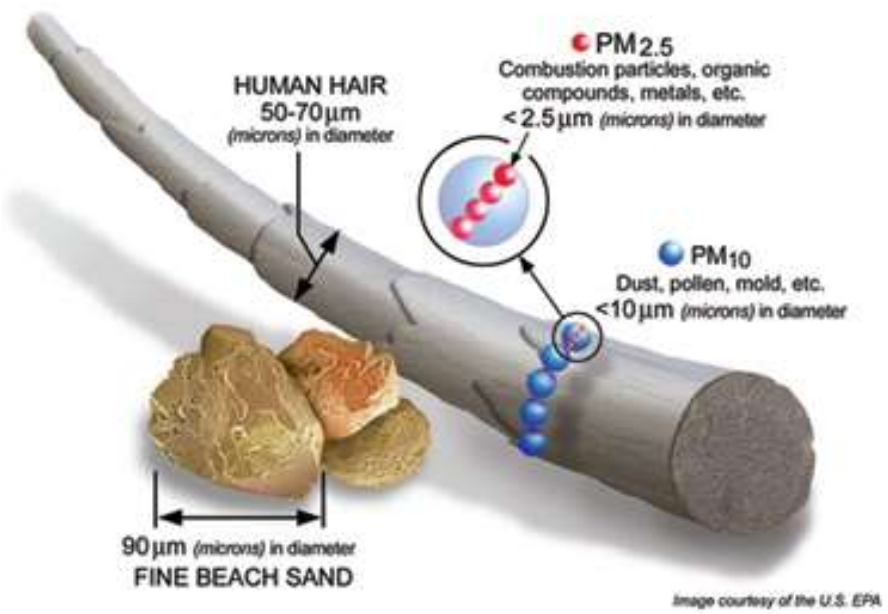


- Source: EPA/DCCAE

PM: The problem pollutant

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

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



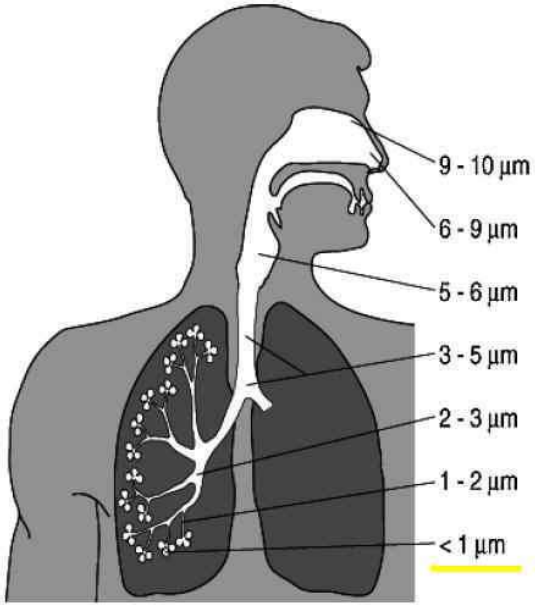


Figure 2 Particle deposition in respiratory system

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 EEA/WHO Reports

European Environment Agency:
Air pollution remains the single largest environmental health hazard in Europe

- Ireland– over 1,100 premature deaths every year

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

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

Emerging Research:

Toxic air pollution particles found in human brains

The Guardian 05/09/2018

Detection of 'abundant' magnetite particles raises concerns because of suggested links to Alzheimer's disease

▲ The new study examined brain tissue from people in the UK and Mexico and found abundant particles of magnetite, an iron oxide. Photograph: Manuel Velasquez/Getty Images

Air pollution particles found in mothers' placentas

The Guardian 16/09/2018

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

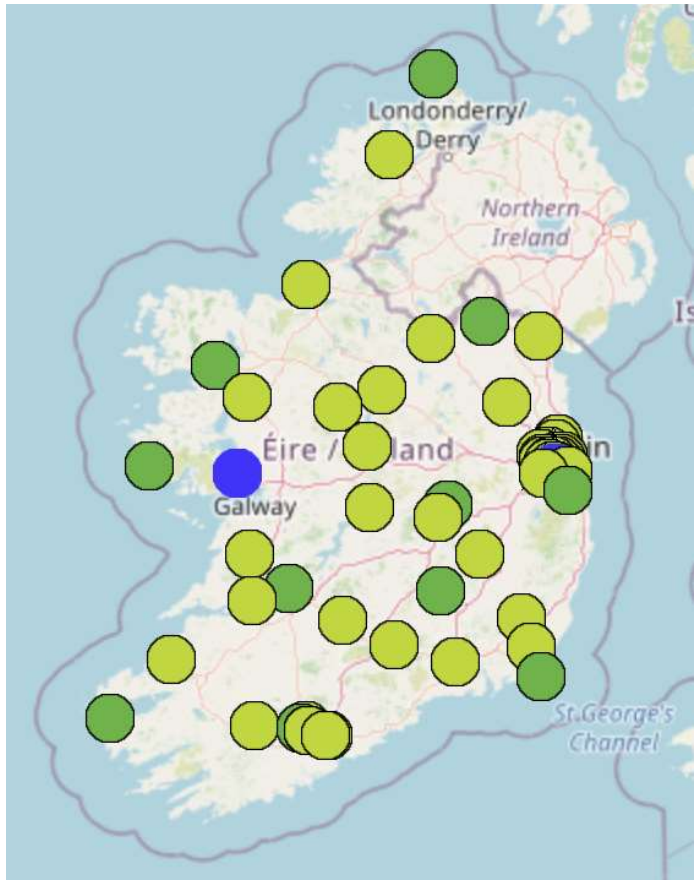
▲ The new study, involving mothers living in London, revealed sooty particles in their placentas. Photograph: Keith Levit/Alamy Stock Photo

Air Quality Standards

EU Air Quality Directive				WHO Guidelines	
Pollutant	Averaging Period	Objective and legal nature and concentration	Comments	Concentration	Comments
$PM_{2.5}$	Hourly			25 µg/m³	99th percentile (3 days/year)
$PM_{2.5}$	Annual	Limit value, 25 µg/m³		10 µg/m³	
PM_{10}	Hourly	Limit value, 50 µg/m³	Not to be exceeded on more than 35 days per year	50 µg/m³	99th percentile (3 days/year)
PM_{10}	Annual	Limit value, 40 µg/m³		20 µg/m³	
O_3	Maximum daily 8-hour mean	Target value, 120 µg/m³	Not to be exceeded on more than 25 days per year, averaged over three years	100 µg/m³	
NO_2	Hourly	Limit value, 200 µg/m³	Not to be exceeded on more than 18 times a calendar year	200 µg/m³	
NO_2	Annual	Limit value, 40 µg/m³		40 µg/m³	

- Levels at monitoring sites in Ireland were below the EU legislative limit values in 2018.
- In 2018, Ireland was above World Health Organization (WHO) air quality guideline values at a number of monitoring sites for $PM_{2.5}$, ozone (O_3) and nitrogen dioxide (NO_2).

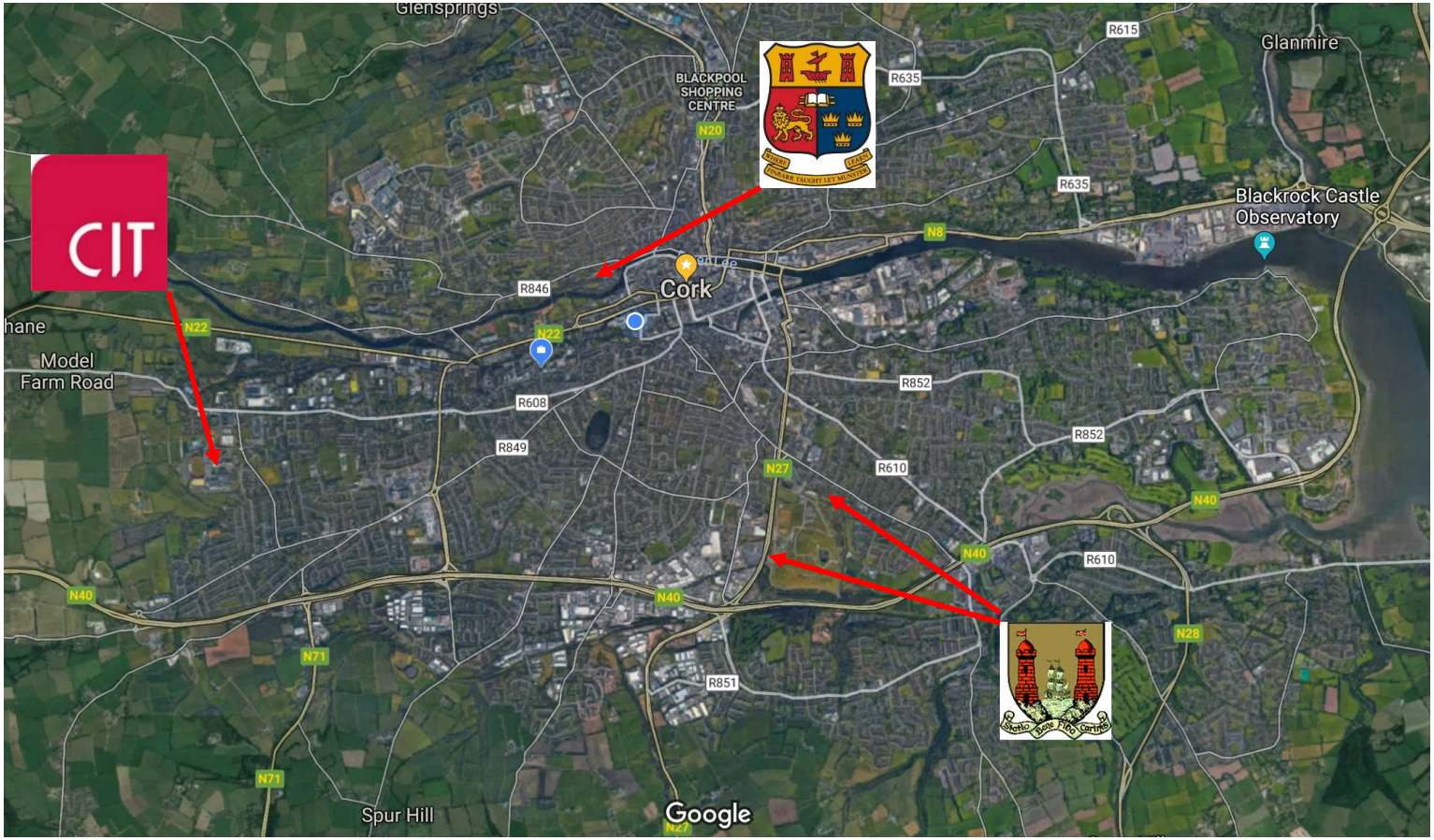
Air Quality Monitoring in Ireland



https://www.epa.ie/air/quality/data/

https://www.epa.ie/pubs/reports/air/quality/epaairqualityreport2018.html

Monitoring Stations in Cork



UCC Atmospheric Monitoring Station

Official opening 28 May 2018

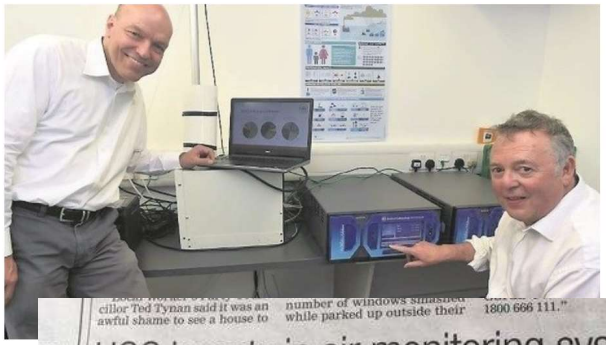
UCC Atmospheric Monitoring Station

RTÉ News Sport Entertainment Business Lifestyle Culture Player TV Radio More

News > Munster | Ireland World Business Politics Nuacht Investigations Programmes Bre

Station detailing air pollution levels in Cork city in operation

Updated / Wednesday, 30 May 2018 **16:50**



cillor Ted Tynan said it was an awful shame to see a house to

number of windows smashed while parked up outside their

1800 666 111."

UCC invests in air monitoring system

■ Darragh Bermingham

THE urgent need to monitor the quality of the air in Cork has prompted UCC to invest €66,000 in a new atmospheric monitoring station.

The station will be part of the Centre for Research into Atmospheric Chemistry in partnership with the Environmental Research Institute at UCC. Air pollution is responsible for 1,660 premature deaths in Ireland every year, research has shown.

Recent results from an 'air pollution walk' carried out by UCC showed that parts of Cork City can reach harmful particulate levels similar to those found in London.

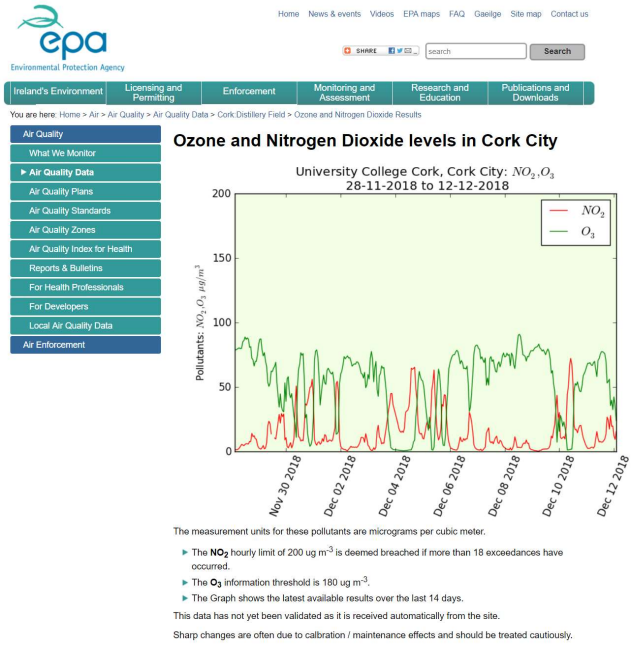
For those who suffer from asthma and other chronic breathing or cardio difficulties, any real-time 'early warning' information about air quality may prove life-saving.

The new monitoring facility, based in the North Mall Campus, is part of UCC's green flag initiative and will be run in collaboration with the Environmental Protection Agency (EPA) and Met Éireann. The prominent air pollutants ozone and nitrogen dioxide will be continuously monitored, along with very fine dust particles (particulate matter) that are invisible to the human eye and negatively impact on human health, especially the old and young.

Professor John Sodeau, founding Director of the Centre for Research into Atmospheric Chemistry said: "Our own health and well-being depend upon the health of the atmosphere.

"Unless we monitor air pollutants accurately and in real-time we simply cannot diagnose the extent to which life-changing effects like heart failure, stroke and cancer will occur."

- Real-time reporting of air pollution in Cork city on the EPA's National Air Quality Monitoring Network



https://www.epa.ie/air/quality/data/corkdistilleryfield/

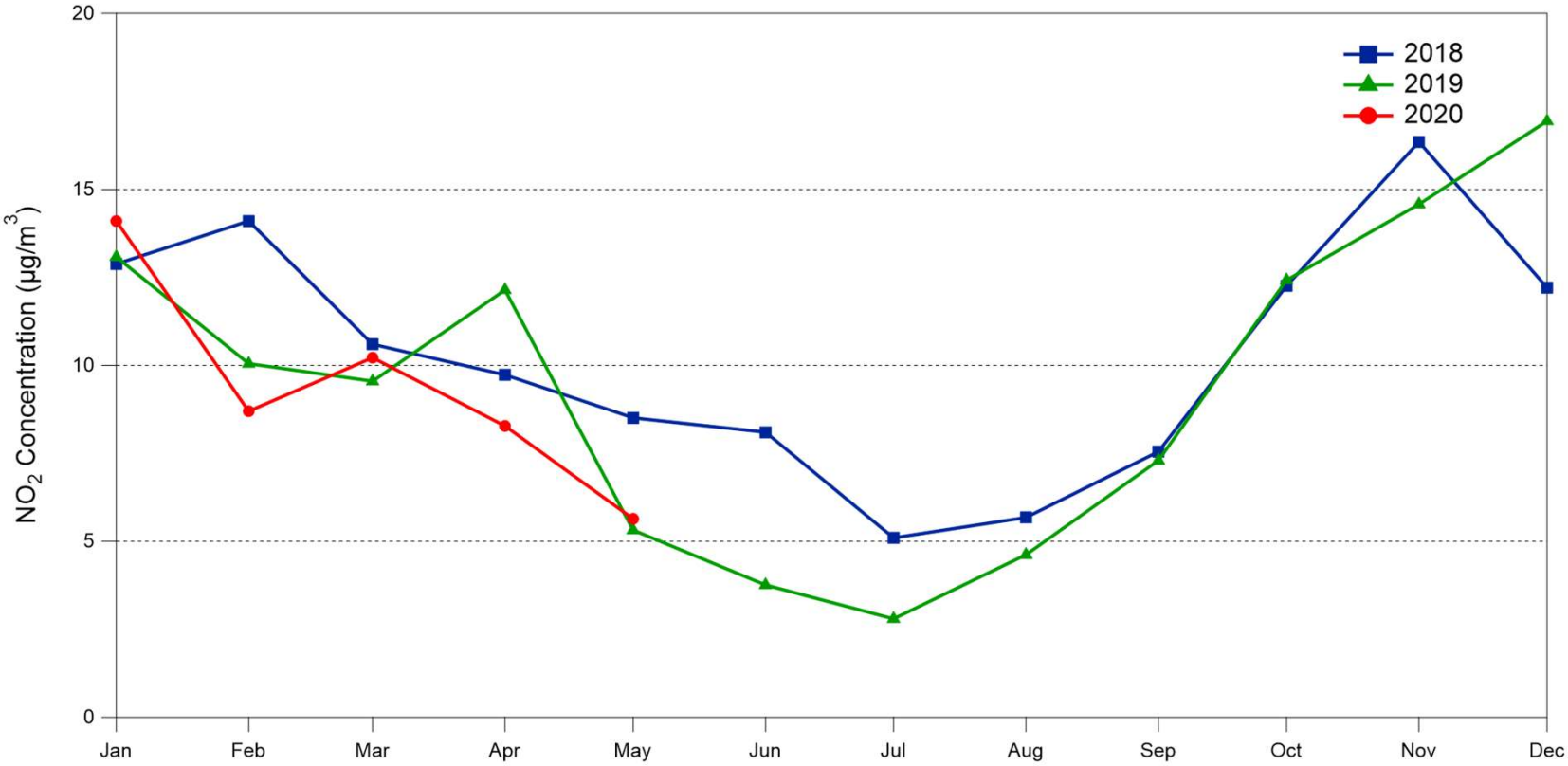
Environmental Research Institute

UCC Atmospheric Monitoring Station

Beta Attenuation Monitor (BAM) for $PM_{2.5}$

Automated analyzers for nitrogen oxides and ozone

Nitrogen Dioxide: Monthly average values



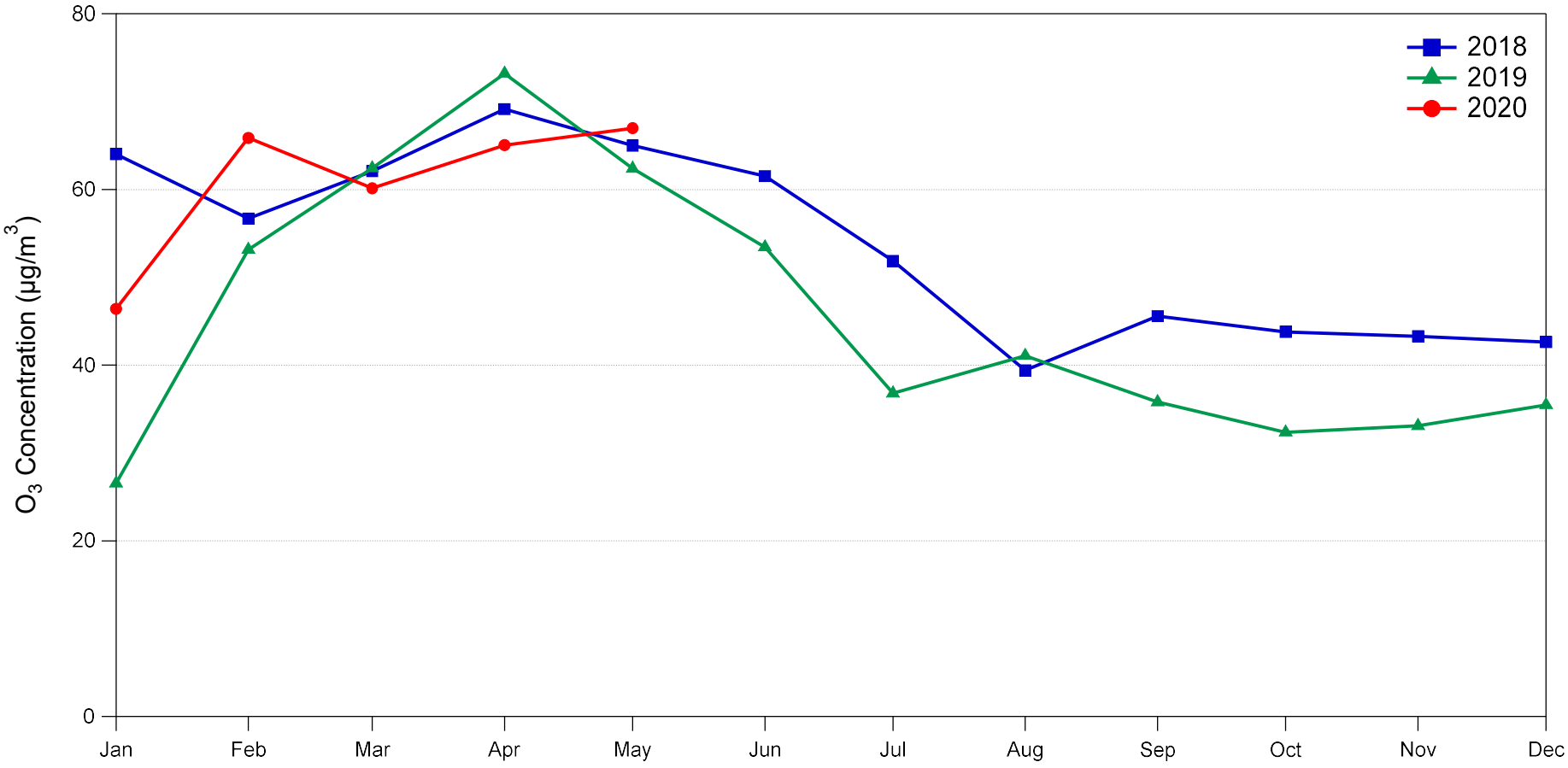
- Mainly emitted from road vehicles
- Drops during summer – less emissions and higher rate of removal by photochemistry

NO_2 + sunlight → NO + O (g)

$O + O_2 \rightarrow O_3$ ozone formation

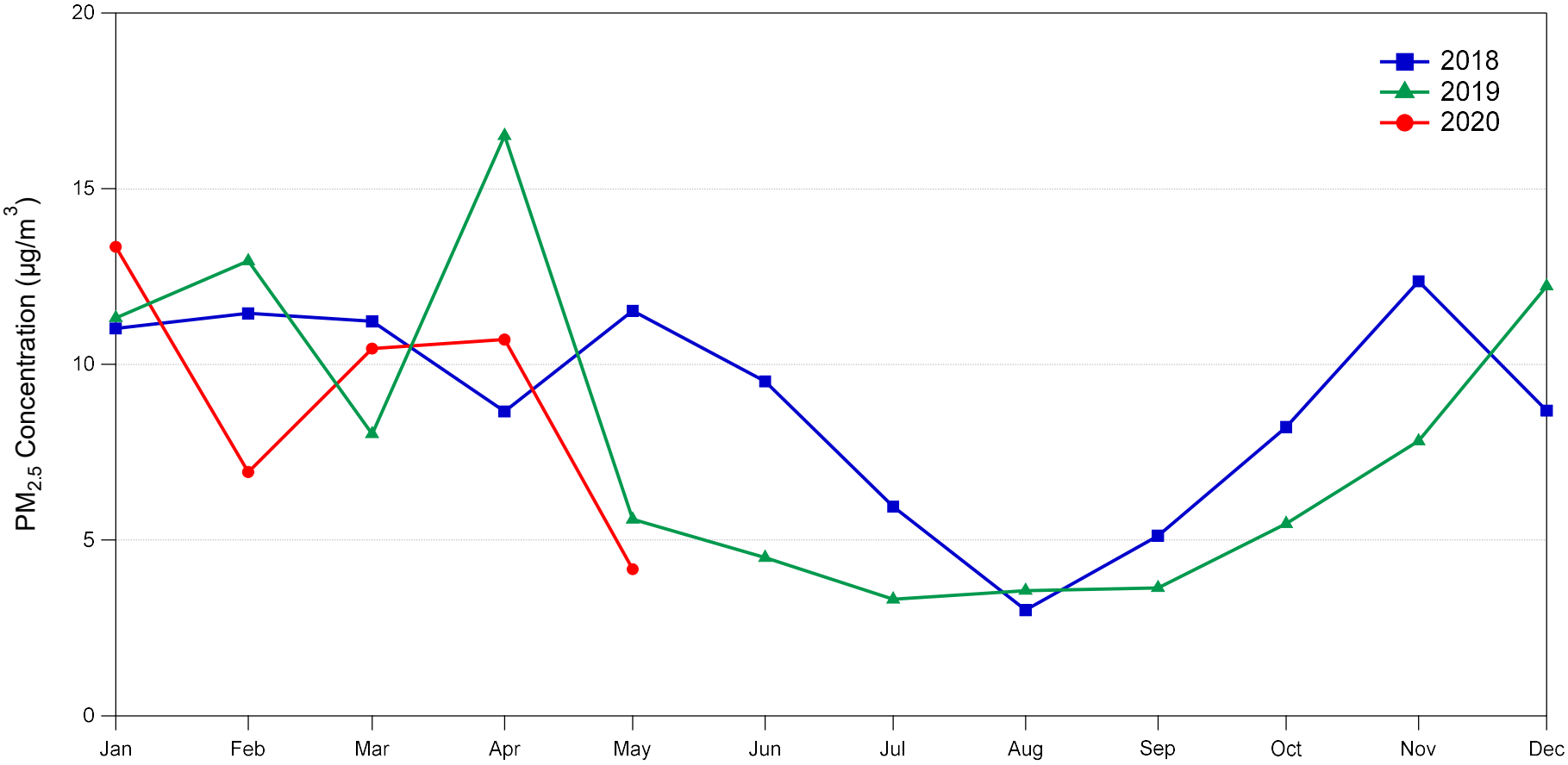
$NO + O_3 \rightarrow NO_2 + O_2$ ozone loss

Ozone: Monthly average values



- Maximum observed during late Spring

$PM_{2.5}$: Monthly average values

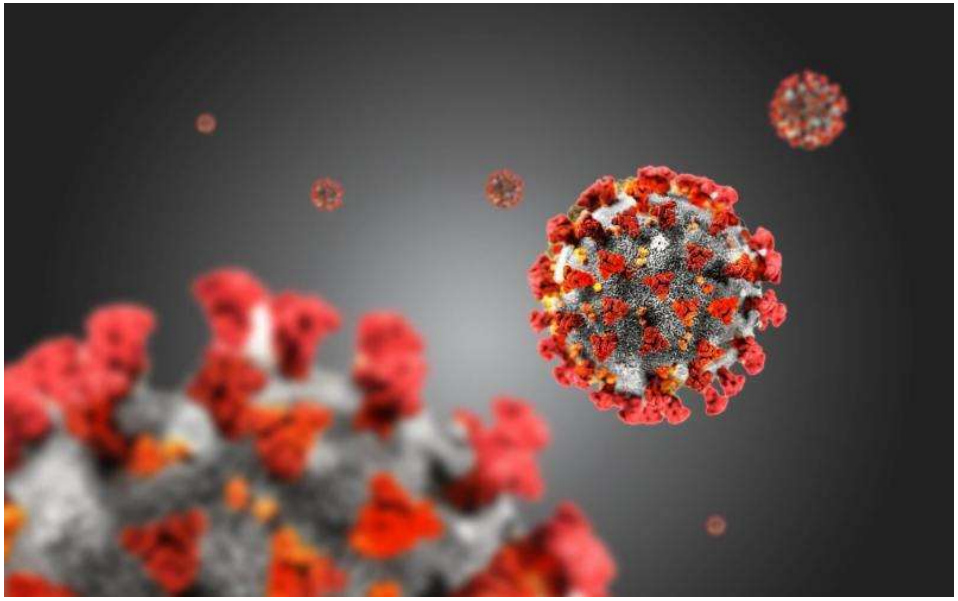


- Maximum observed during winter months due to residential solid fuel burning

Annual Averages

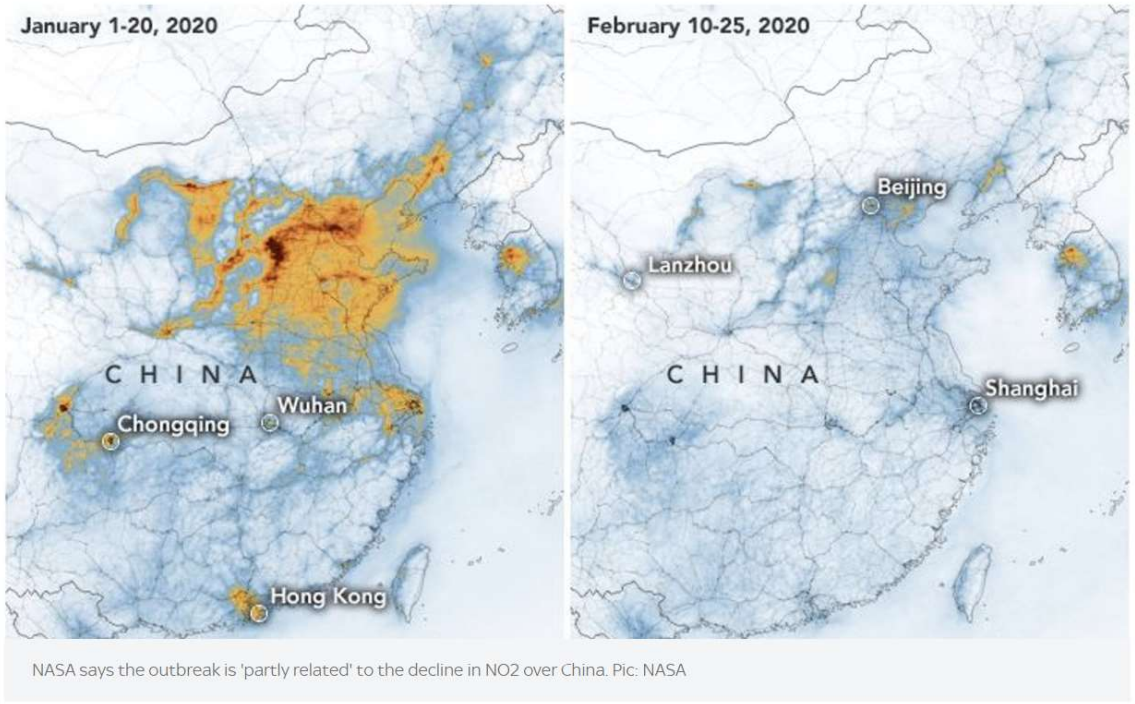
	UCC Station	EU Limit	WHO Guideline
$PM_{2.5}$ ($\mu g/m^3$)	8.8 (2018) 7.9 (2019)	25	10
NO_2 ($\mu g/m^3$)	10.3 (2018) 9.4 (2019)	40	40
O_3 ($\mu g/m^3$)	52.7 (2018) 45.4 (2019)		

Values typical of urban background in Ireland



How has COVID-19 affected air quality?

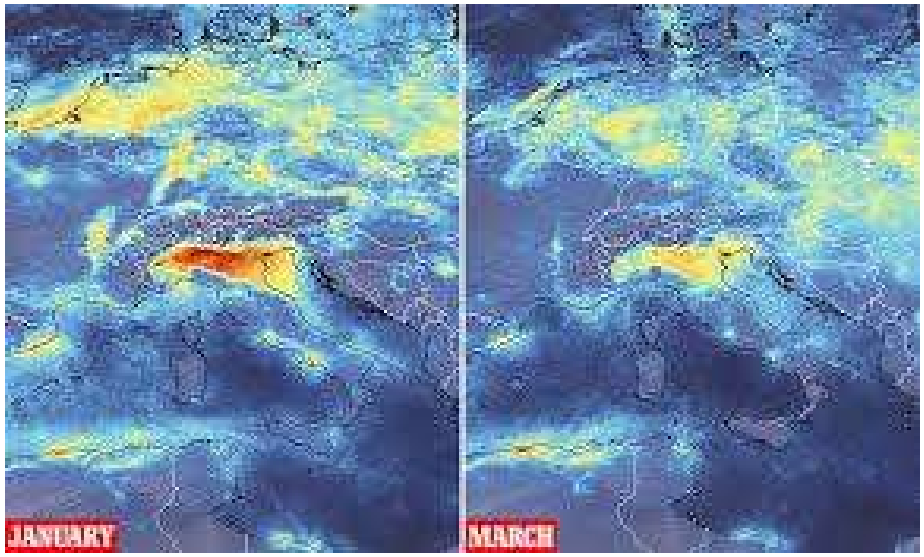
Impact of COVID-19 in China and Italy



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 in India

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

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

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

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

Impact of COVID-19 on Air Quality: Early publication - India

Science of the Total Environment 730 (2020) 139086

Contents lists available at ScienceDirect

Science of the Total Environment

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

Effect of lockdown amid COVID-19 pandemic on air quality of the megacity Delhi, India

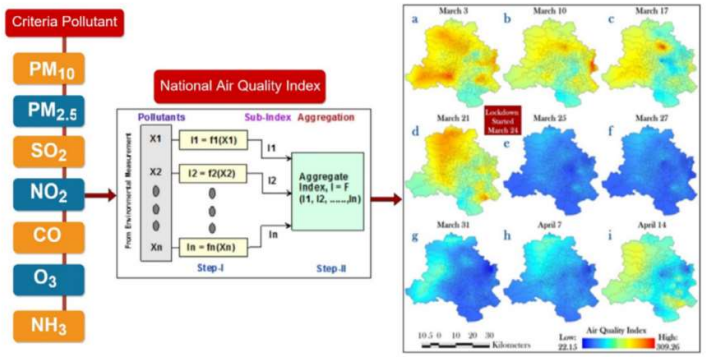
Susanta Mahato, Swades Pal, Krishna Gopal Ghosh *

Department of Geography, University of Gour Banga, West Bengal, India
Department of Geography, Presidency University, West Bengal, India

HIGHLIGHTS

- PM_{10} and $PM_{2.5}$ concentrations reduced by about half in compare to the pre-lockdown
- NO_2 and CO have also shown considerable decline during lockdown.
- In the transportation and industrial location air quality have improved close to 60%.
- The central and Eastern Delhi have experienced maximum improvement in air quality.
- On the 2nd and 4th day of lockdown, about 40% to 50% improvement in air quality

GRAPHICAL ABSTRACT



https://www.sciencedirect.com/science/article/pii/S0048969720326036?via%3Dihub

Impact of COVID-19 on Air Quality: Early publication – China/ES/IT

Contents lists available at ScienceDirect

Science of the Total Environment

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

Amplified ozone pollution in cities during the COVID-19 lockdown

Pierre Sicard [a], Alessandra De Marco [b,*], Evgenios Agathokleous [c], Zhaozhong Feng [c,*], Xiaobin Xu [d], Elena Paoletti [e], José Jaime Diéguez Rodriguez [f], Vicent Calatayud [f]

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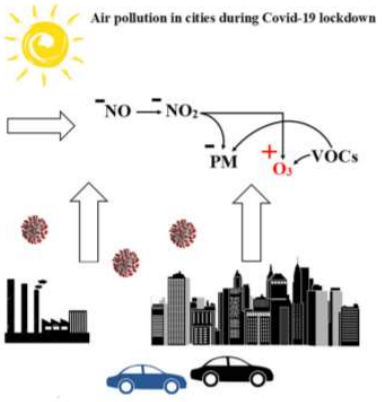
[b] Italian National Agency for New Technologies, Energy and the Environment, C.R. Casaccia, Italy
[c] Institute of Ecology, Key Laboratory of Agro-meteorology of Jiangsu Province, School of Applied Meteorology, Nanjing University of Information Science and Technology, Nanjing, China
[d] State Key Laboratory of Severe Weather and Key Laboratory for Atmospheric Chemistry of China Meteorology Administration, Chinese Academy of Meteorological Sciences, Beijing, China
[e] Institute of Research on Terrestrial Ecosystems, National Research Council, Sesto Fiorentino, Italy
[f] Fundación CEAM, Parque Tecnológico, C/ Charles R. Darwin, 14, Paterna, Spain

HIGHLIGHTS

- Air quality during the COVID-19 lockdown in 4 European and 1 Chinese cities
- The lockdown caused a substantial reduction in NO_x in all cities (~ 56%)
- Reductions in PM were much higher in Wuhan (~ 42%) than in Europe (~ 8%)
- The lockdown caused an ozone increase in all cities (17% in Europe, 36% in Wuhan)
- The lockdown effect on O_3 production was higher than the weekend effect

GRAPHICAL ABSTRACT



- Lower emissions of NO result in removal of ozone loss process

$$NO + O_3 \rightarrow NO_2 + O_2$$ ozone loss

https://www.sciencedirect.com/science/article/pii/S0048969720330590?via%3Dihub

Impact of COVID-19 on Air Quality in Ireland

THE IRISH TIMES

Air pollution falls dramatically in parts of Ireland following travel restrictions

Environmental Protection Agency reports decreases of up to 50% in nitrogen-dioxide at its air quality stations around the country

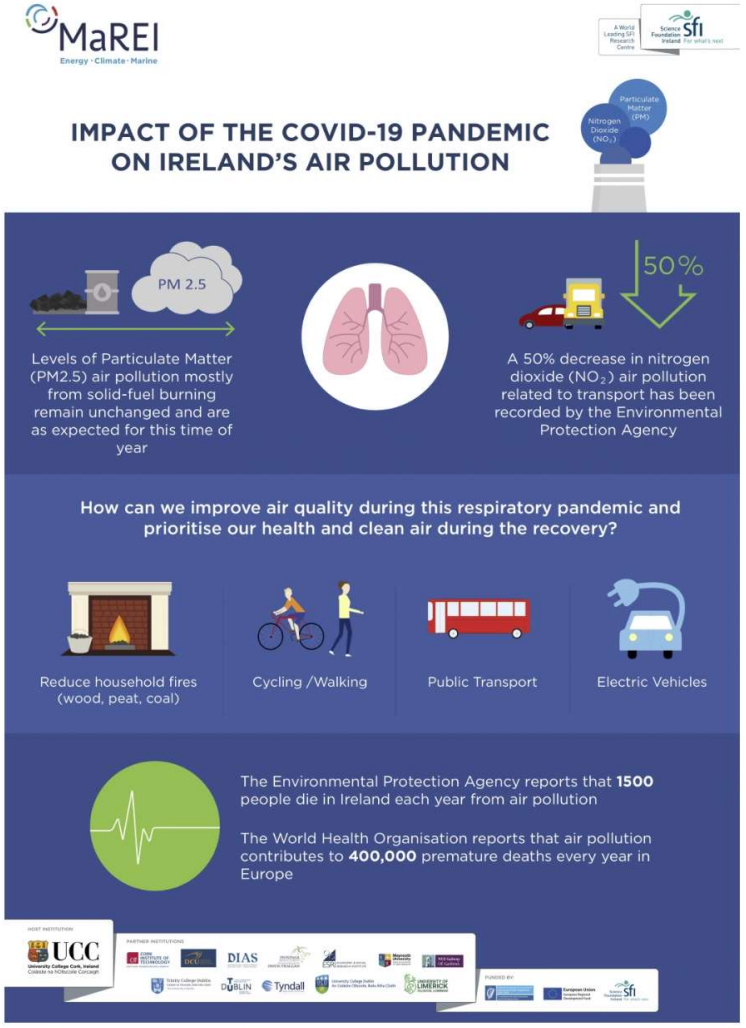
Thu, Apr 9, 2020, 19:35

Brian Hutton

Petrol and diesel vehicles are the main producer of nitrogen-dioxide in Ireland's air, although industry and power plants also contribute to pollution levels. Photograph: Getty Images

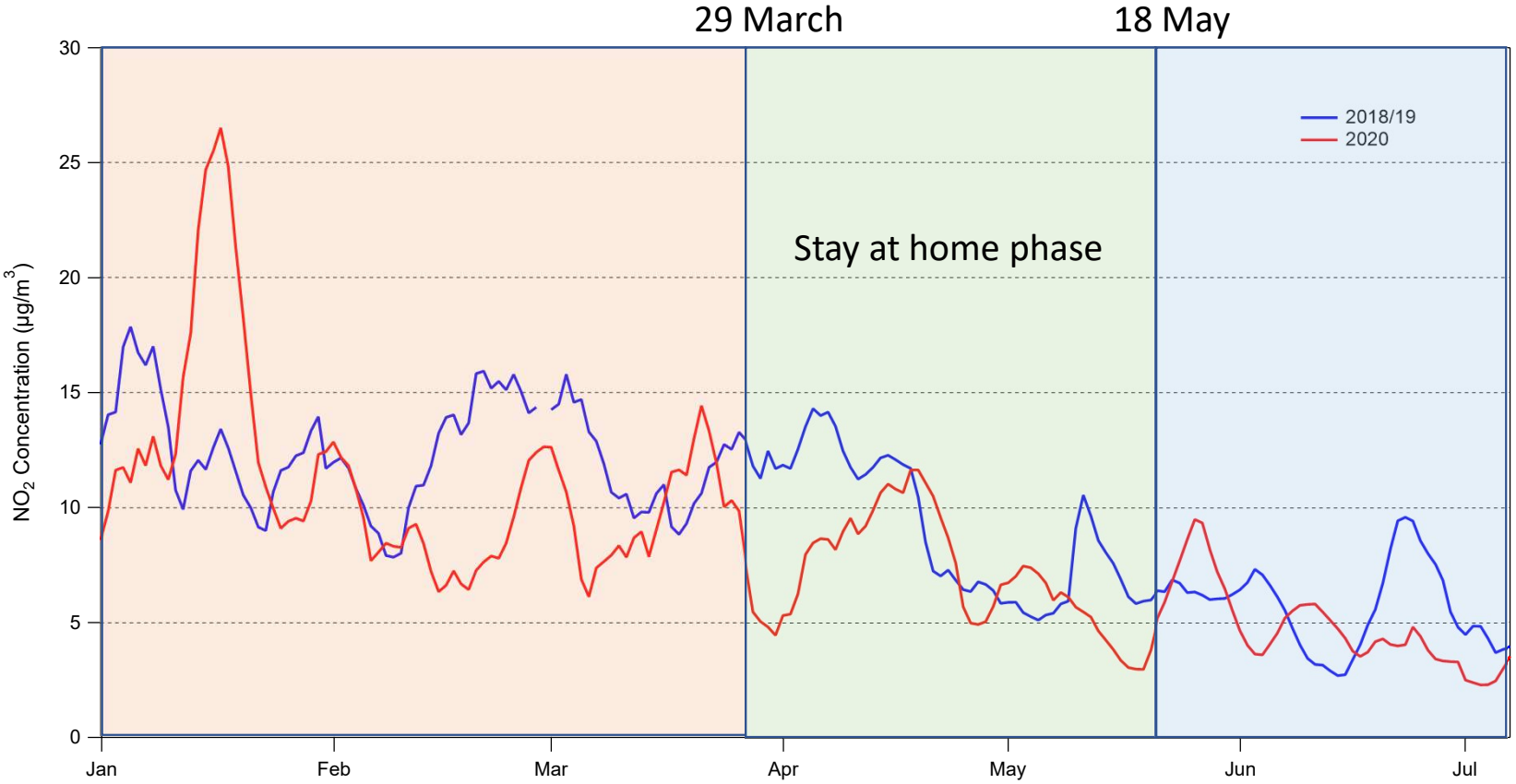
https://www.irishtimes.com/news/ireland/irish-news/air-pollution-falls-dramatically-in-parts-of-ireland-following-travel-restrictions-1.4225401

epa Environmental Protection Agency



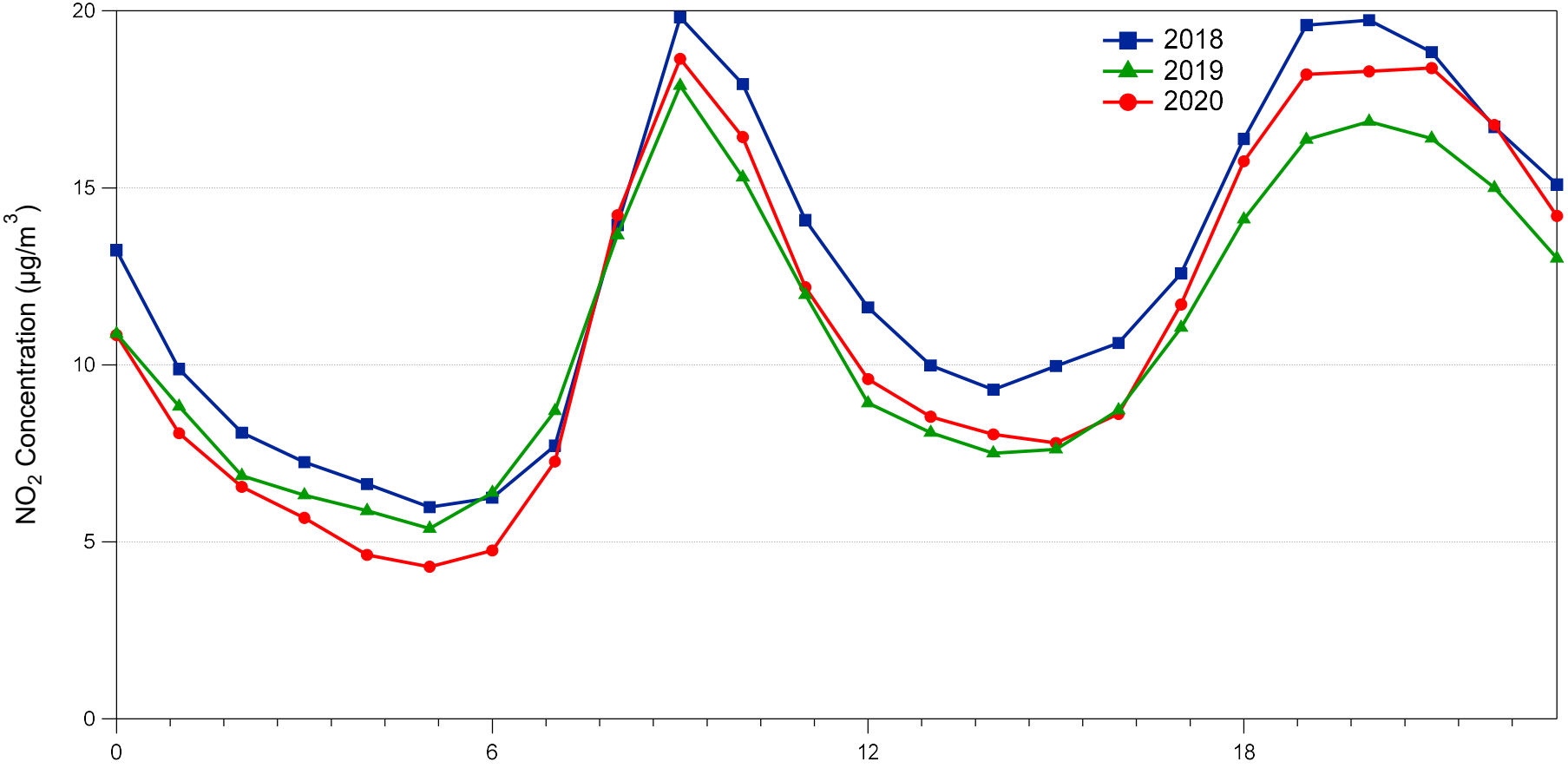
https://www.marei.ie/marei-covid-19-analysis/

Impact of COVID-19 in Cork (UCC Station, Niall O'Sullivan)



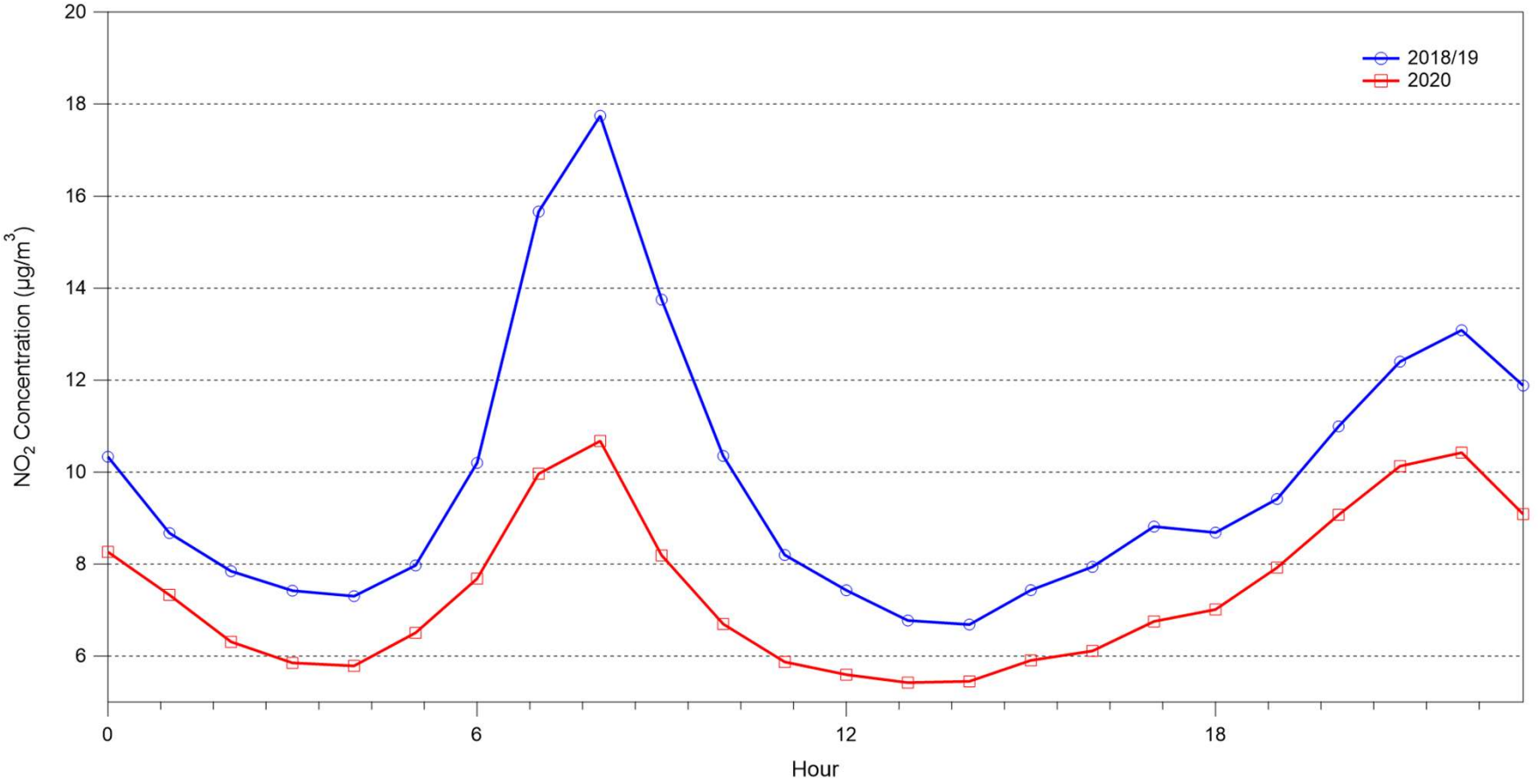
- 7 day moving average for NO_2 in 2020 compared with average for 2018 and 2019

Nitrogen Dioxide: Diurnal Variation (1 Jan to 28 March)



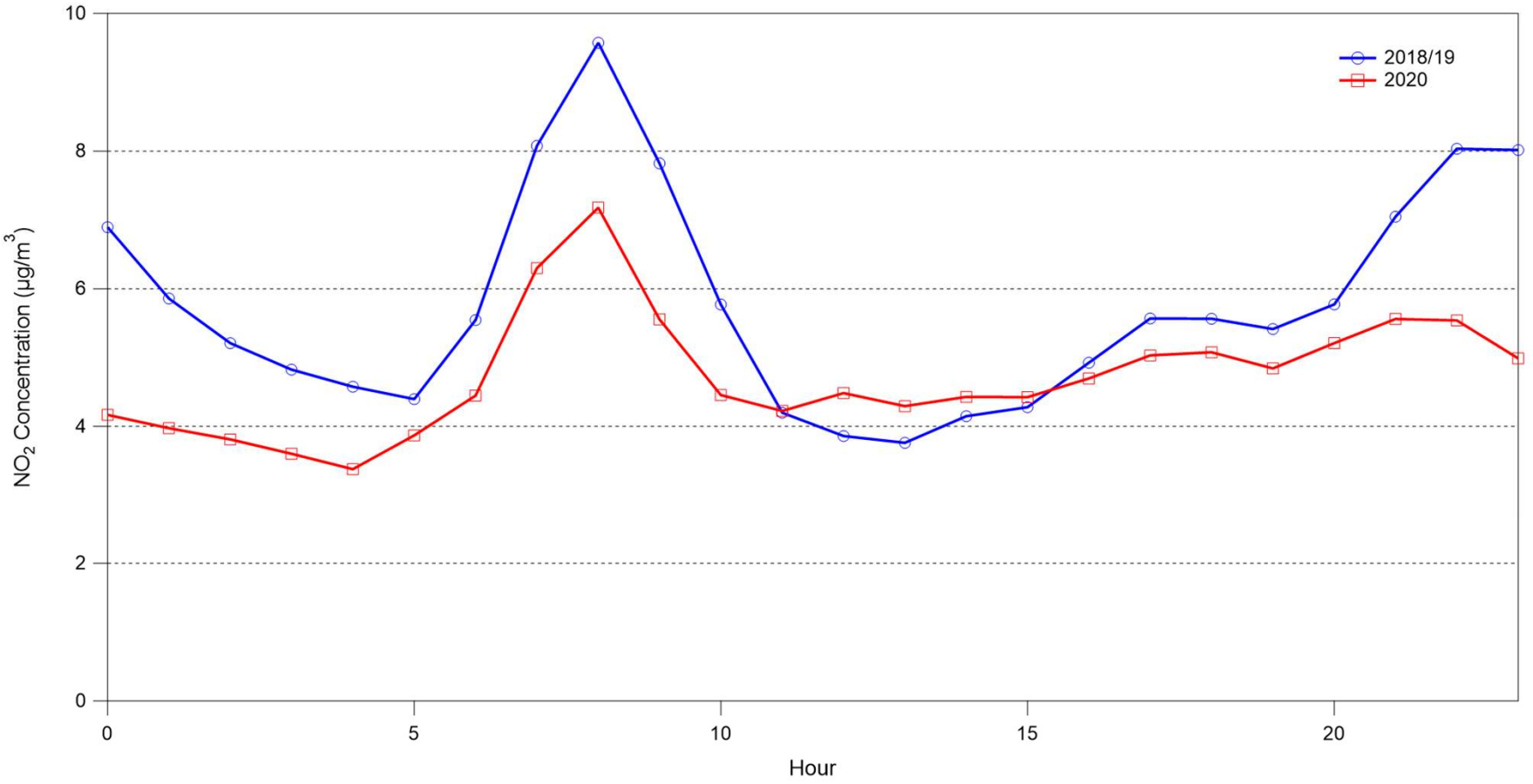
- Very consistent from year to year
- Sharp morning peak (traffic) and broader evening peak (traffic plus solid fuel burning)

Nitrogen Dioxide: Diurnal Variation (29 March to 17 May)



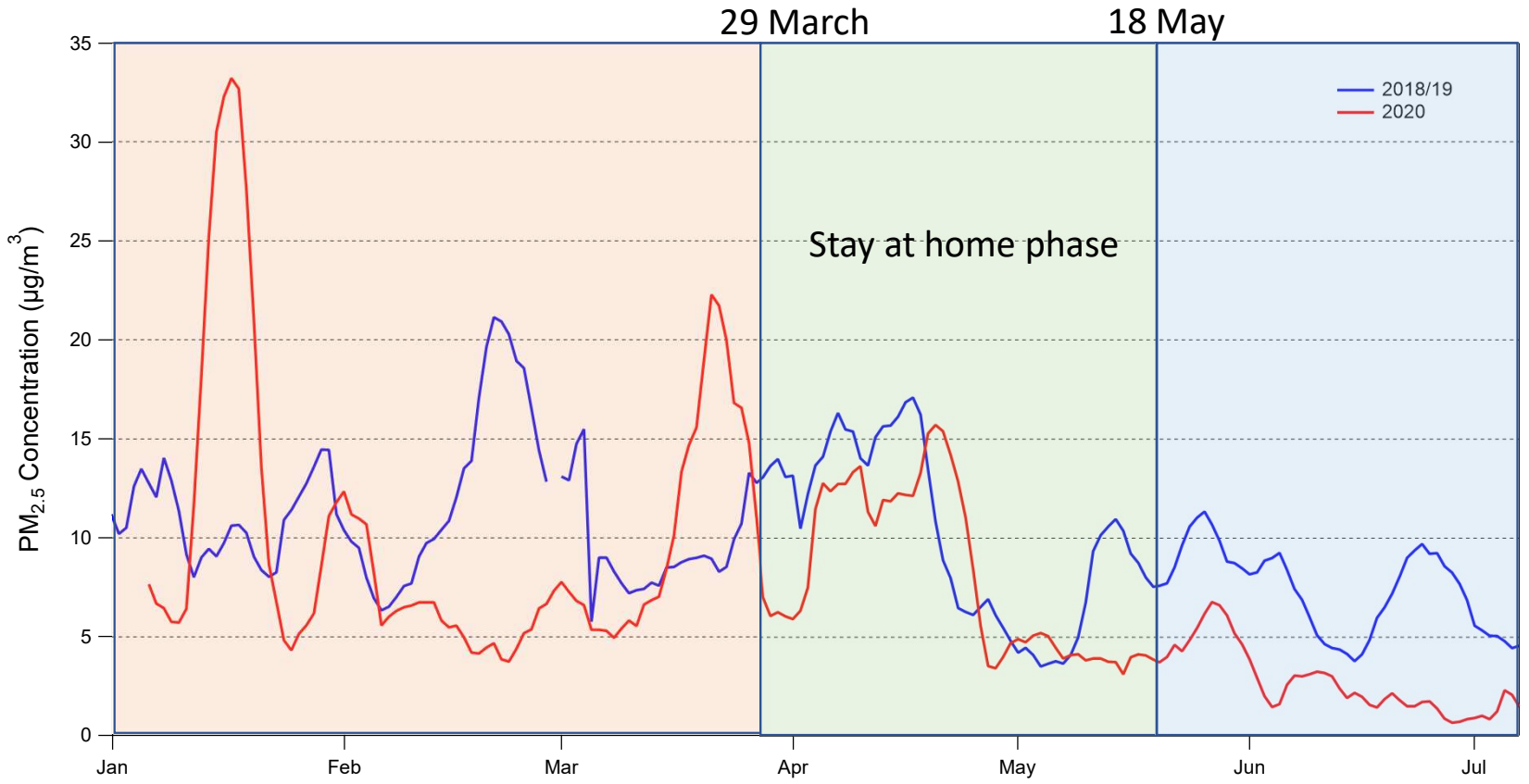
- 25% drop in NO_2 during 2020 compared to average of 2018/2019 for the same period

Nitrogen Dioxide: Diurnal Variation (18 May to 7 July)



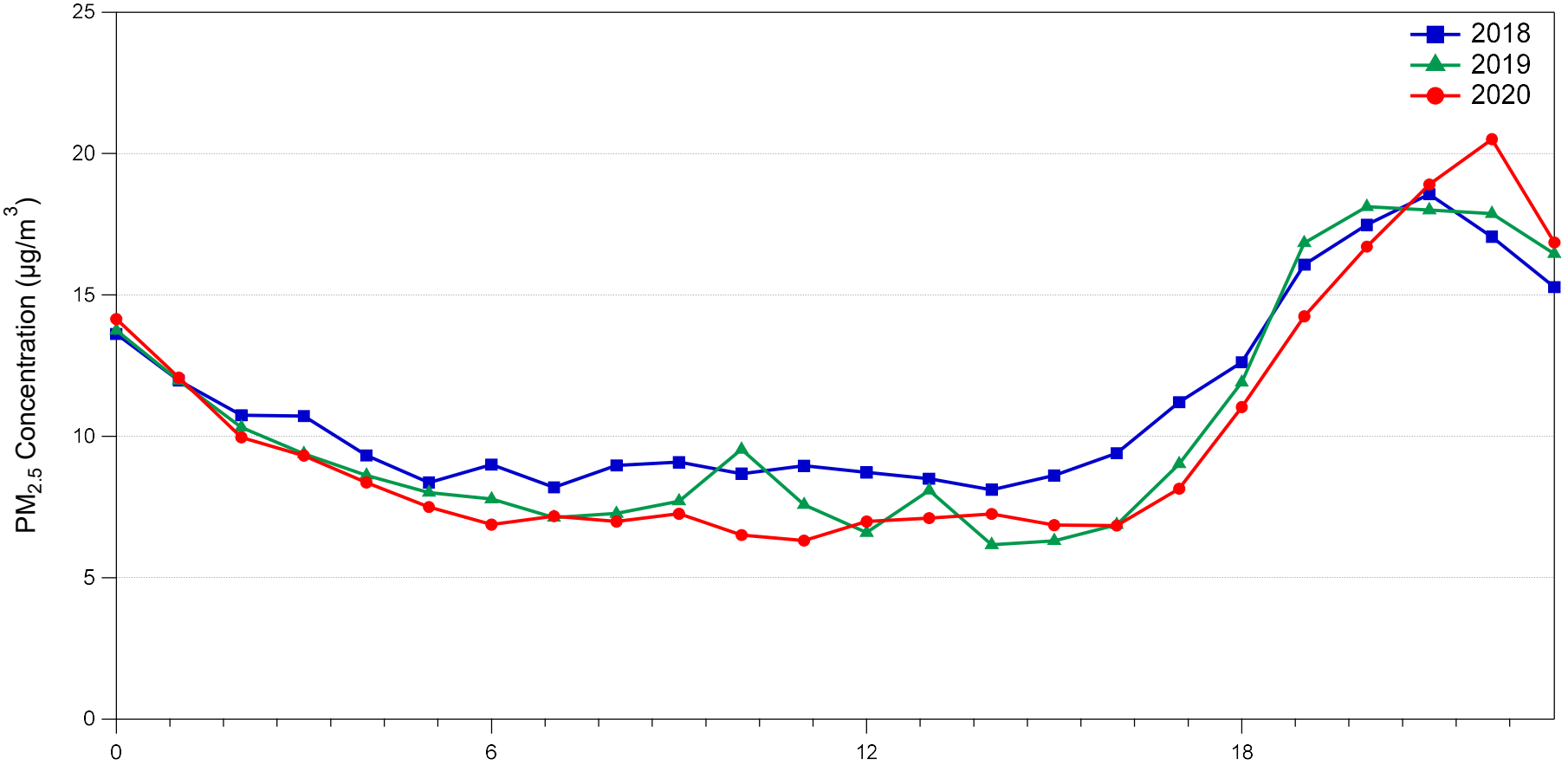
- 19% drop in NO_2 during 2020 compared to average of 2018/2019 for the same period

Impact of COVID-19 in Cork (UCC Monitoring Station)



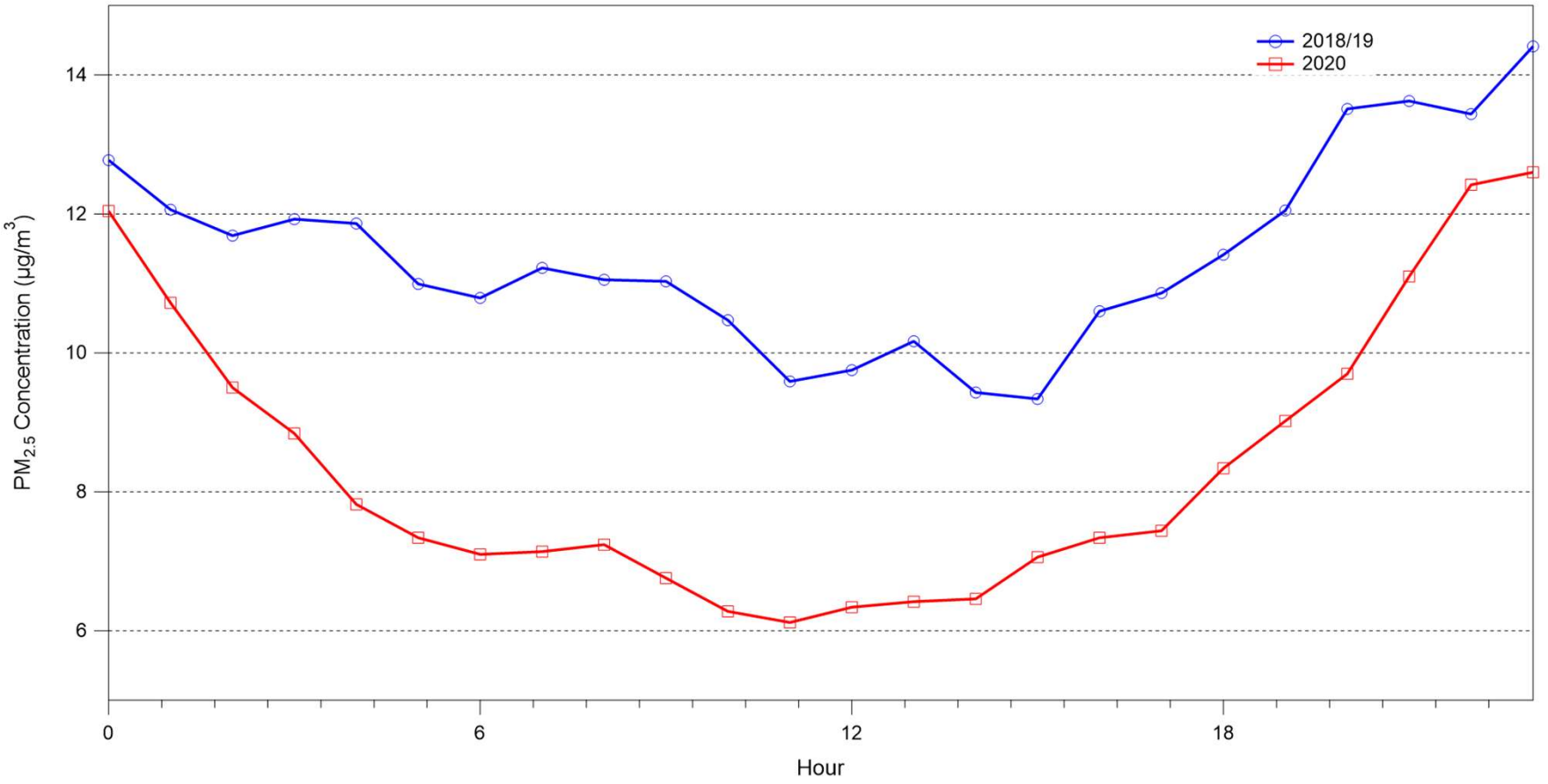
- 7 day moving average for $PM_{2.5}$ in 2020 compared with average for 2018 and 2019

$PM_{2.5}$: Diurnal Variation (1 Jan to 28 March)



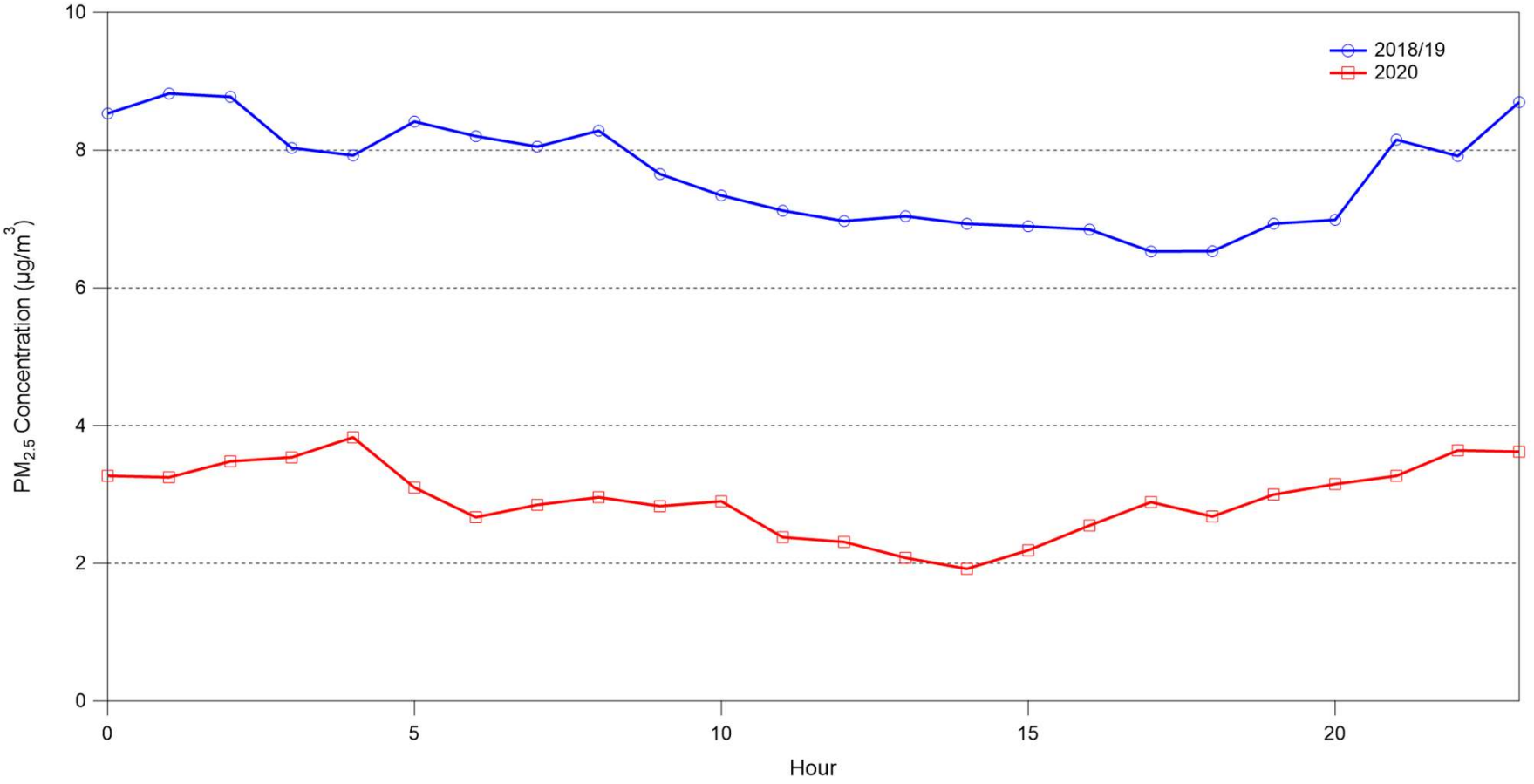
- Very consistent from year to year
- Broad evening peak due to residential solid fuel burning

$PM_{2.5}$: Diurnal Variation (29 March to 17 May)



- 27% drop in 2020, although April 2019 does have an unusually high average

$PM_{2.5}$: Diurnal Variation (18 May to 7 July)



- 62% drop in 2020 compared with average for 2018 and 2019

Impact of COVID-19 in Cork (UCC Monitoring Station)

	NO_2 Concentration	$PM_{2.5}$ Concentration	O_3 Concentration
2018/19 Avg 01-Jan – 28-Mar	12.54	10.87	56.50
2018/19 Avg 29-Mar – 17-May	9.88	11.43	68.61
2018/19 Avg 18-May – 07-Jul	5.80	7.65	55.89
2020 01-Jan – 28-Mar	11.23	10.19	56.82
2020 29-Mar – 17-May	7.42	8.38	61.05
2020 17-May – 07-Jul	4.72	2.93	58.24
Percentage difference during lockdown period (Average of 2018/19 compared to 2020)	-25%	-27%	-11%
Percentage difference after lockdown period (Average of 2018/19 compared to 2020)	-19%	-62% (skewed by v large 2018)	+4%

- This is a simple analysis - variations in meteorology are not directly taken into account….but could be averaged out.

A more sophisticated type of analysis (Stig Hellebust)

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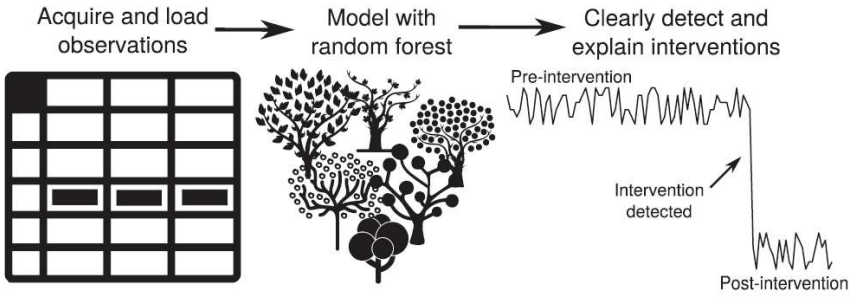
[b] Ricardo Energy & Environment, Harwell, Oxfordshire OX11 0QR, United Kingdom

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



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:

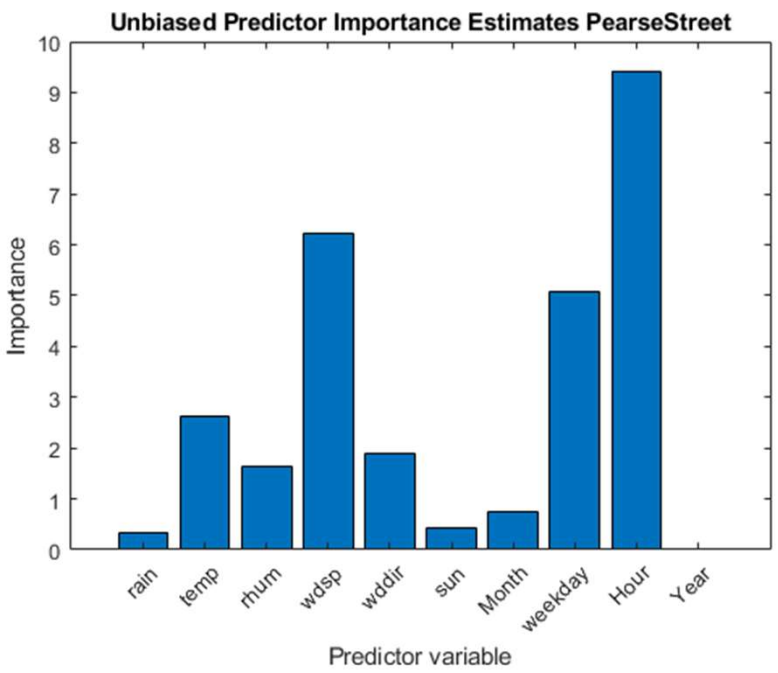
  wind speed, wind direction, rain, temperature, relative humidity, sunlight hours

  In addition, the following parameters are included:

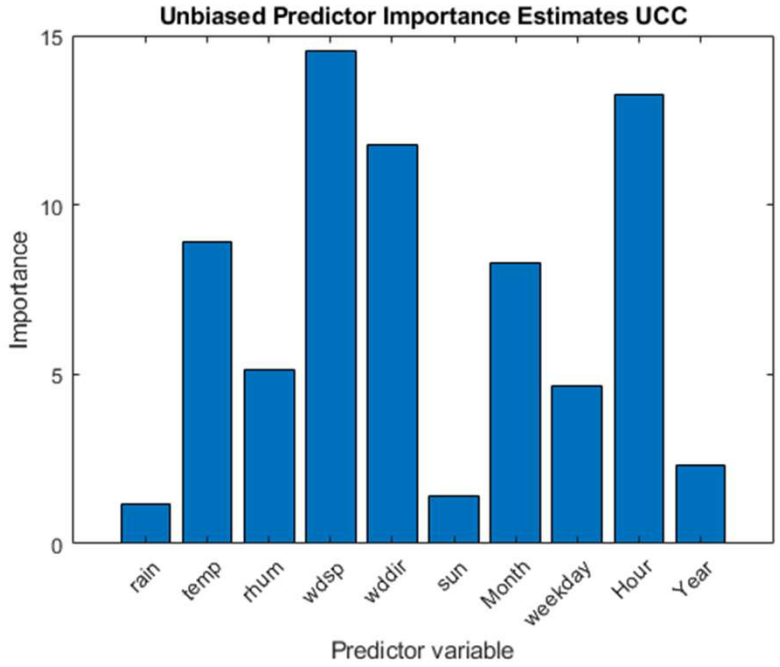
  Hour of the day, day of the week, month and year
- Used a random forest model with an ensemble of 300 regression trees and out-of-bag sampling
- Model predictions validated against the training set (data up till end of 2019)
- Predicted concentrations of pollutants compared to measured values to quantify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

Factors influencing the Model Predictions

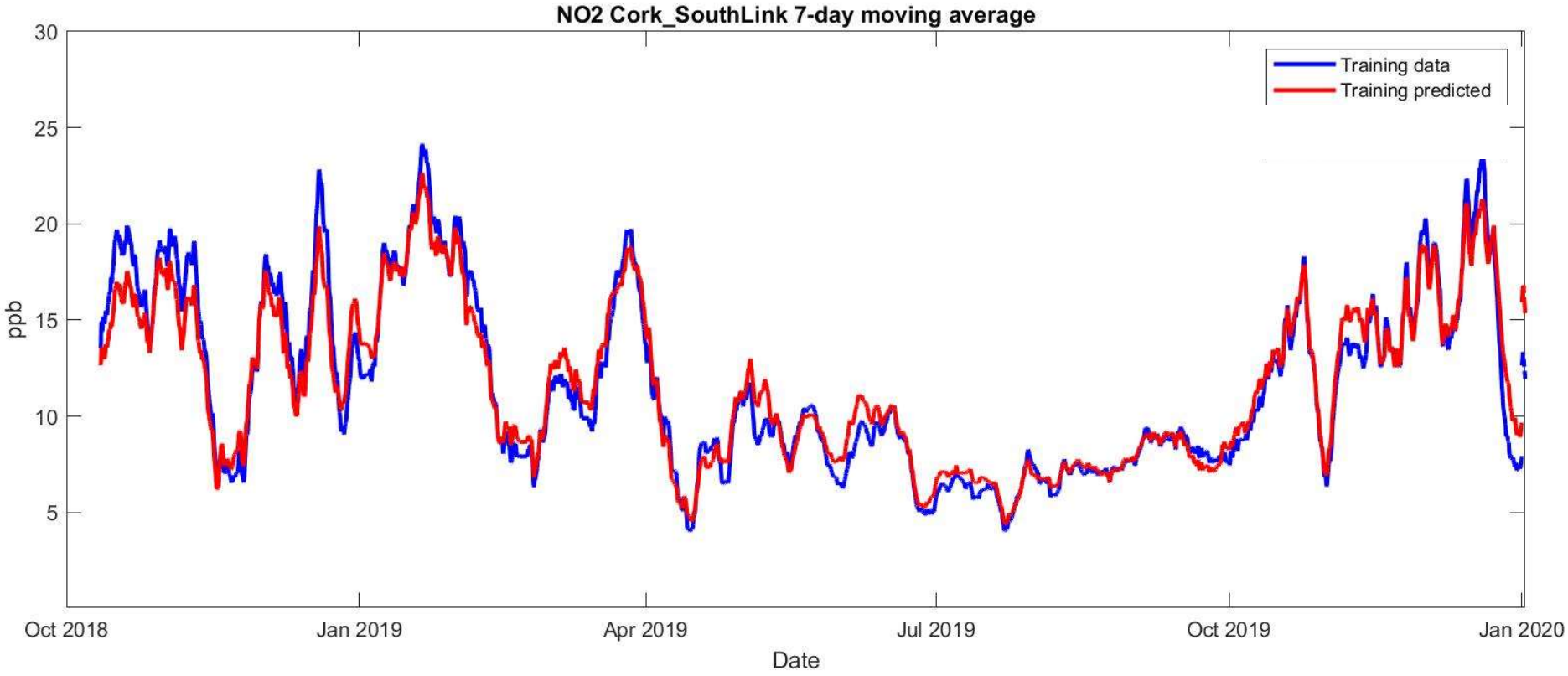
Dublin city roadside (Pearse Street): wind speed, weekday and time of day



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

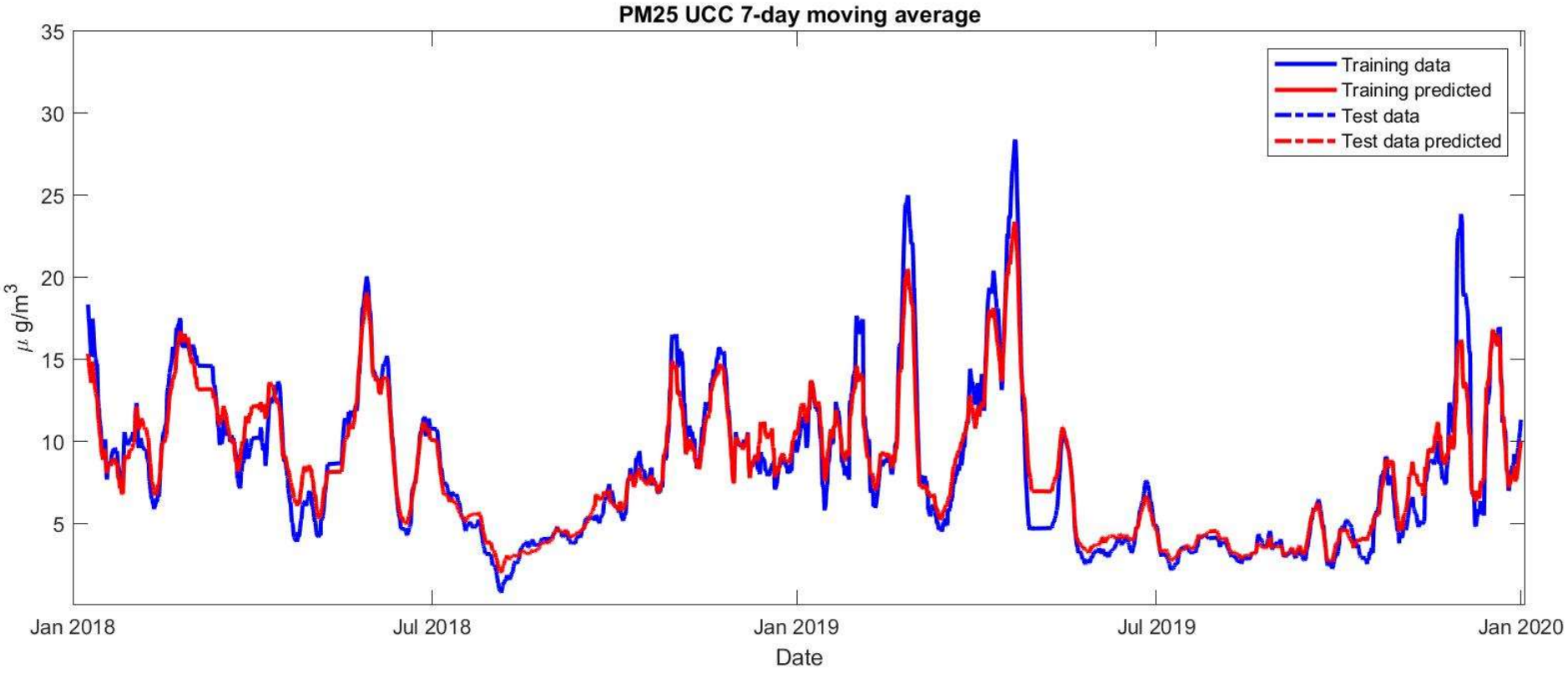


How good are the models?



$R^2 = 0.78$

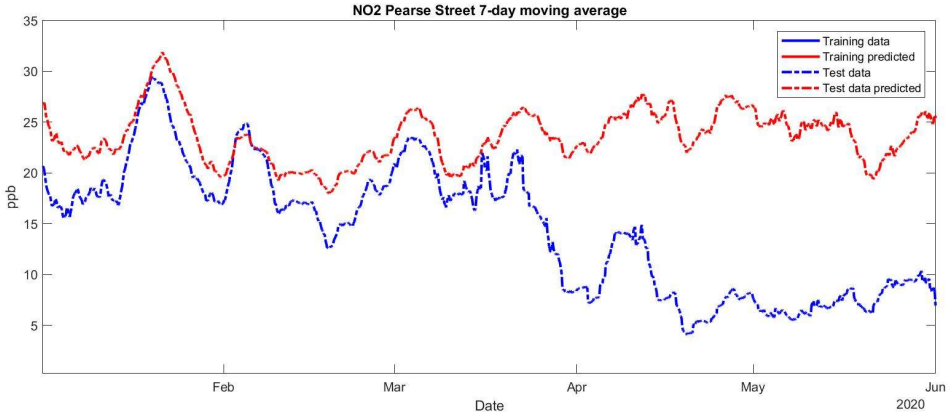
How good are the models?



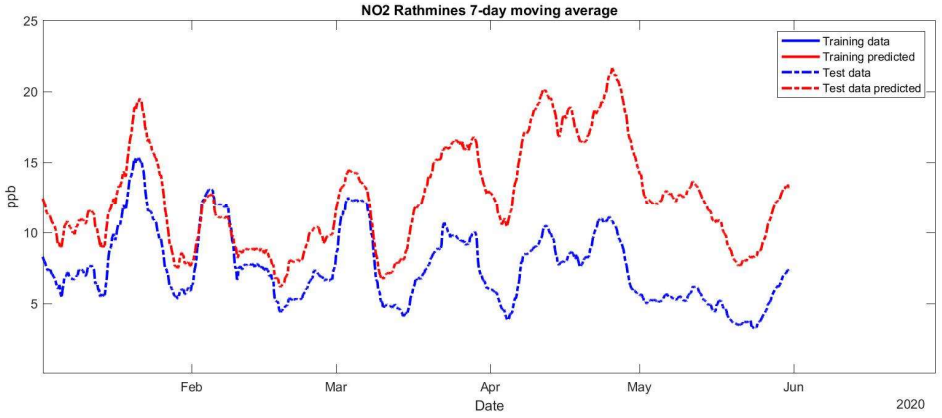
$R^2 = 0.63$

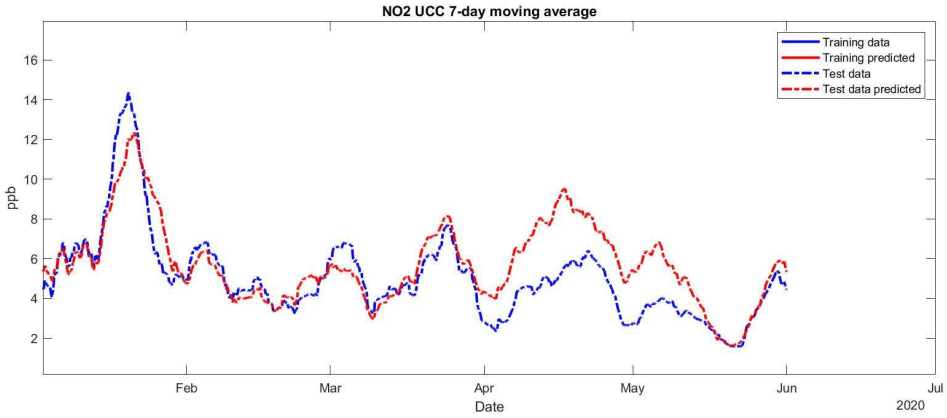
Predicted v Measured NO_2

Dublin Pearse St (57% reduction)



Dublin Rathmines (48% reduction)



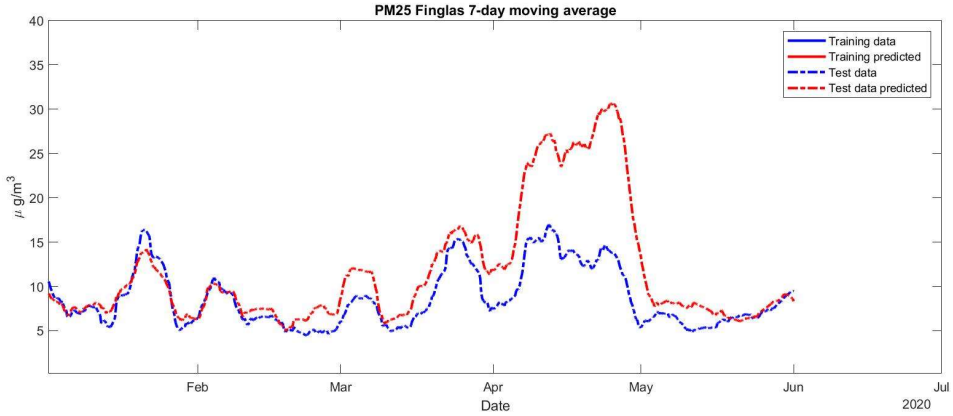


Cork UCC (27% reduction)

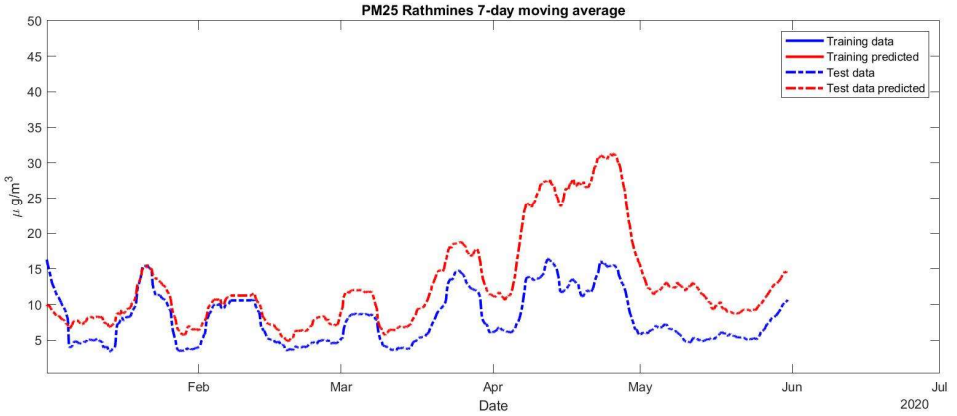
- Reductions observed at all urban sites
- Largest reductions are at roadside locations
- Pollutant levels are still below expected levels at many urban locations
- But hints of a return to business as usual for some locations, e.g. UCC

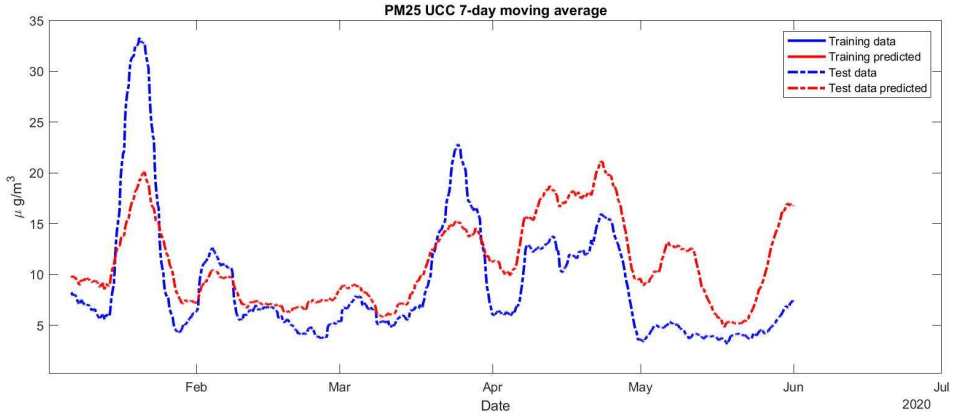
Predicted v Measured $PM_{2.5}$

Finglas (36% reduction)



Dublin Rathmines (47% reduction)



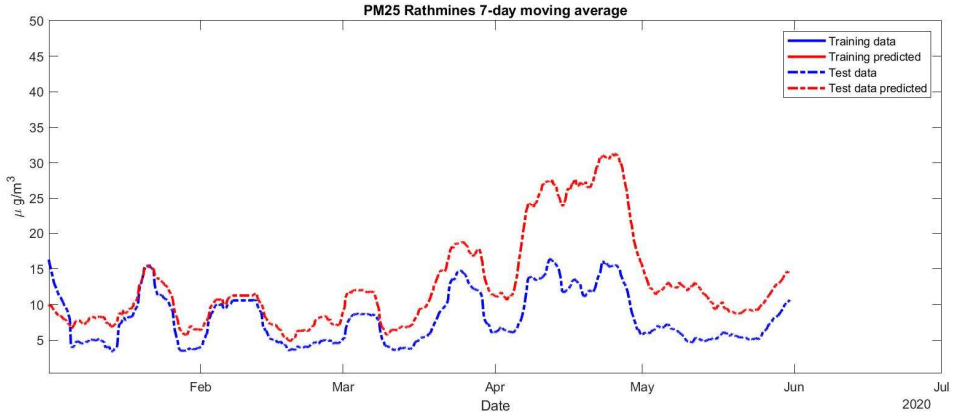


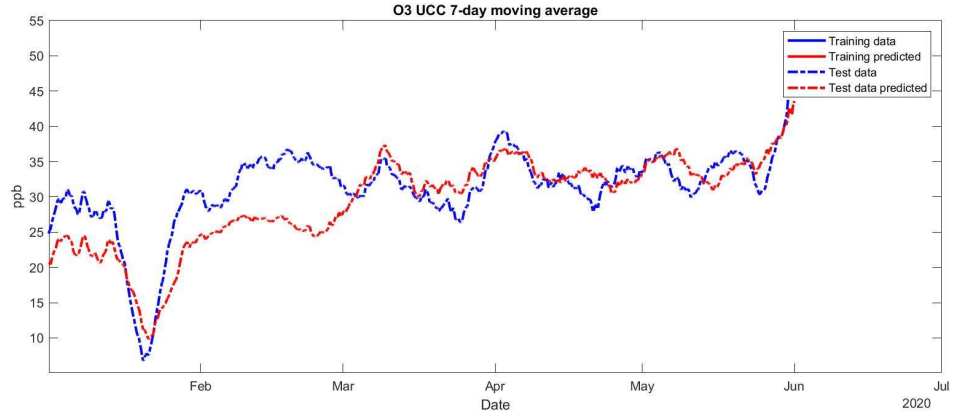
Cork UCC (29% reduction)

- Reductions observed at all urban sites
- Largest reductions are at roadside locations
- Pollutant levels are gradually returning to “normal” for some locations, e.g. Finglas

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

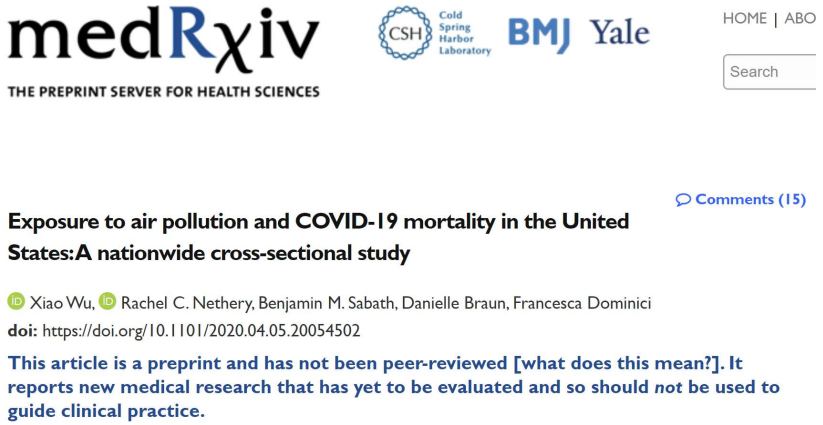
Summary

- Greatest impact of COVID-19 restrictions is on NO_2 levels, where reductions of 27-57% were observed at urban sites in Dublin and Cork
- Similar reductions in $PM_{2.5}$ (20-47%) were observed at urban locations, although this somewhat surprising and needs further investigation
- An increase in ozone was observed at two roadside monitoring sites
- 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.
- Further analysis is ongoing

The other link between air pollution and COVID-19

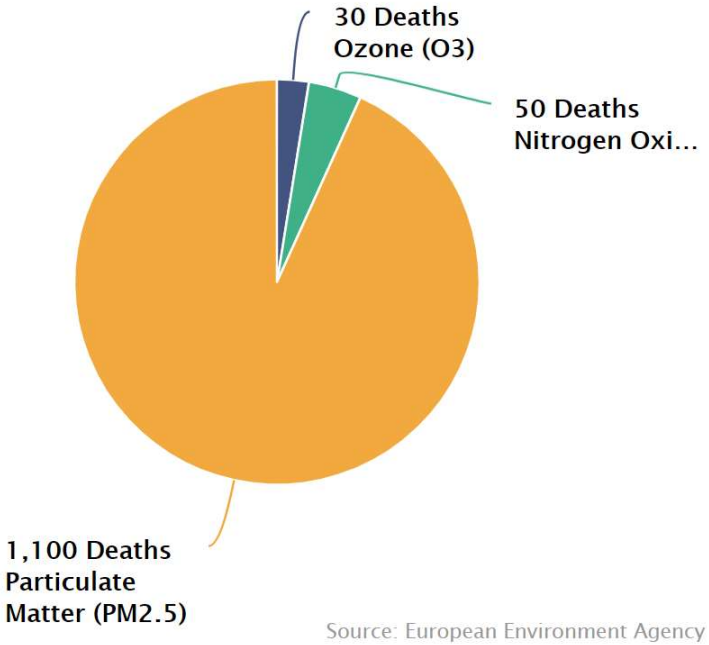
- Exposure to $PM_{2.5}$ causes inflammation and damage to the lining of the lungs over time, weakening the body's ability to fend off respiratory infections.
- It is reasonable to expect that people exposed to higher levels of pollution will be more susceptible to COVID-19 and also have more severe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

- Case fatality rate associated with air pollution index
- SARS patients from regions with high air pollution were twice as likely to die from SARS compared to those from regions with low APIs



- Analysis of COVID-19 deaths and historic $PM_{2.5}$ data (2000-2016)
- An increase of only 1 $\mu g/m^3$ in $PM_{2.5}$ is associated with an 8% increase in the COVID-19 death rate

It is now time to reduce $PM_{2.5}$ emissions

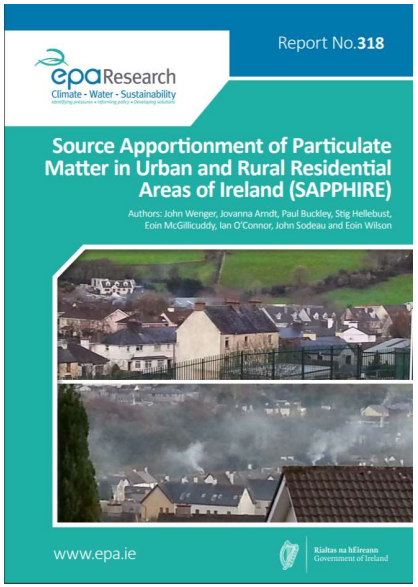


Source: European Environment Agency

- 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 and climate

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

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



Acknowledgements

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- EPA Air quality team

Environmental Research Institute

Q & A

While you're here.....

We have a regular schedule of events, workshops, seminars and outreach activities.

If you would like to hear from us about other ERI events, please email Aoife.Corcoran@ucc.ie

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