

Impacts of the COVID-19 Pandemic on Ambient Air Quality and Atmospheric Composition and Reactivity in the South East of the UK

K. P. Wyche*, M. Nichols, H. Parfitt, P. Beckett,
D. J. Gregg, K. L. Smallbone, P. Lyons, P. S. Monks



University of Brighton

Centre for Earth
Observation Science

Science of the Total Environment. 755, Part 1, 142526

<https://doi.org/10.1016/j.scitotenv.2020.142526>



Natural
Environment
Research Council



University of Brighton

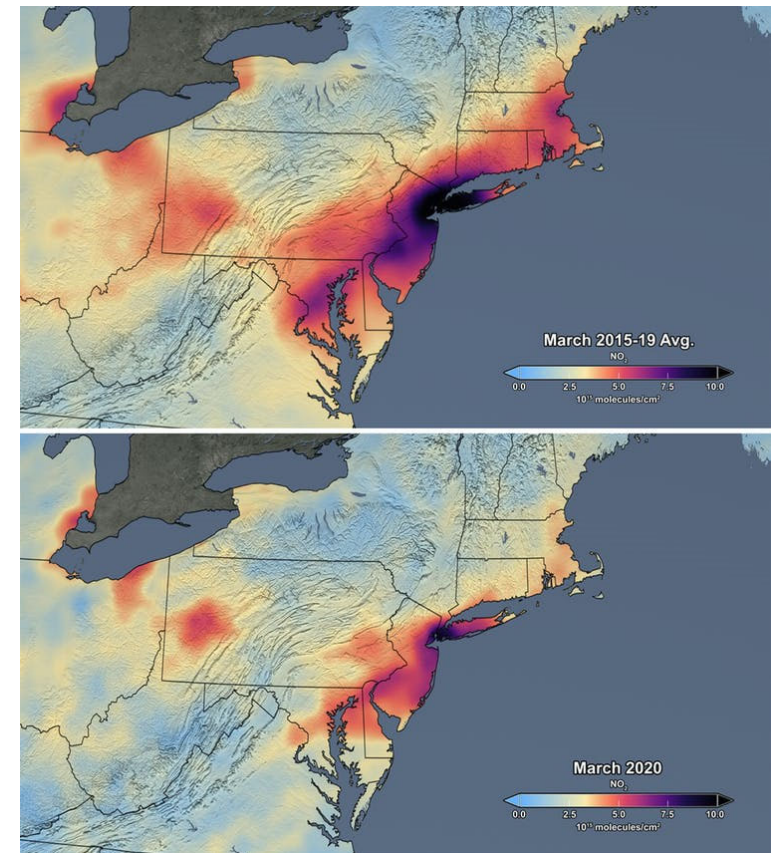
Introduction

Background

- COVID-19 led to reductions in anthropogenic activity and emissions of air pollutants (the 'anthropause')
- Early remote sensing showed NO_2 down by $\sim 30\%$ across China; $\sim 40\%$ across central Europe
- Such dramatic, rapid reduction in air pollutants across species emissions spectrum, globally, is entirely unique -> resultant impacts on chemical processes and composition need investigating

Questions and answering them

- With reductions in NO_x and poorly characterised changes in VOCs what will be the impact on secondary pollutants, inc. O_3 ?
- What will be the impact on oxidative capacity?
- Will we experience a shift in size distribution of particulate numbers?
- How will PM composition change?
- Here we aimed to investigate some of these changes in the SE UK



EPA-EFE/NASA



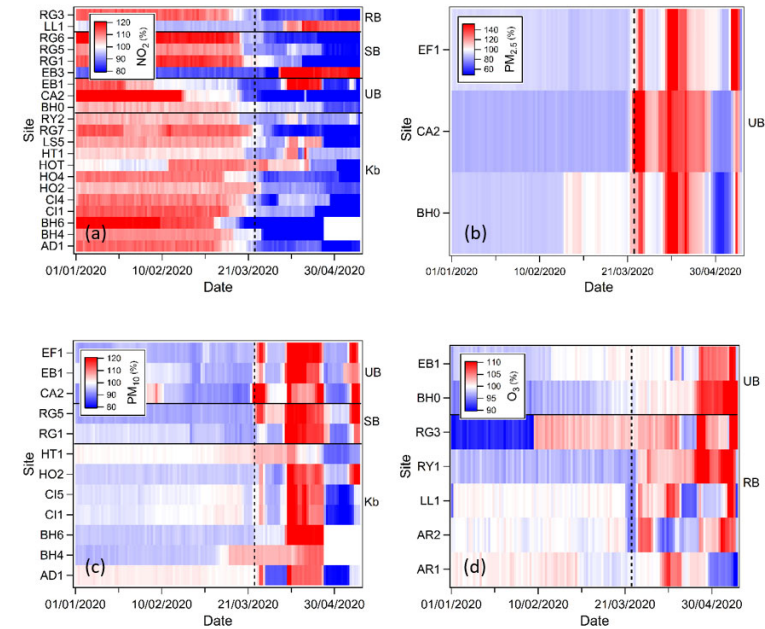
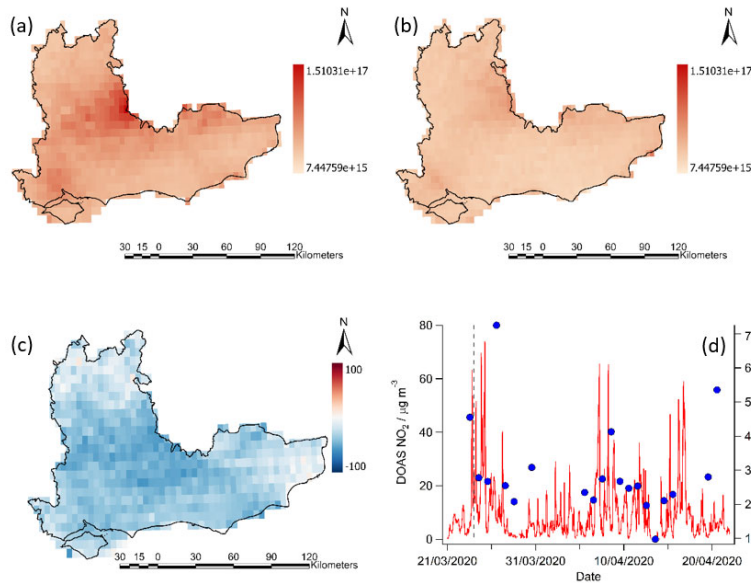
University of Brighton

Methods

- SE UK is a strategic location, having largest regional population (9.13m) and located between 2 major air pollution hotspots (London, industrial NWE)
- Our work was based on measurements made by DEFRA's AURN and AHN, Sussex-Air network, TRL sites, Brighton Atmospheric Observatory (BAO) and ESA's Sentinel-5P satellite
- Total of 27 ground stations with a variety of instruments measuring NO_x , O_3 , HCHO, HONO, HCs, $\text{PM}_{2.5}$ and PM_{10}
- For parts of time-series analyses, data were de-weathered to remove influence of meteorology
- Measurements were supported by OD box modelling using the MCM mechanisms to investigate changes in chemistry and radicals



Results: Broad regional changes

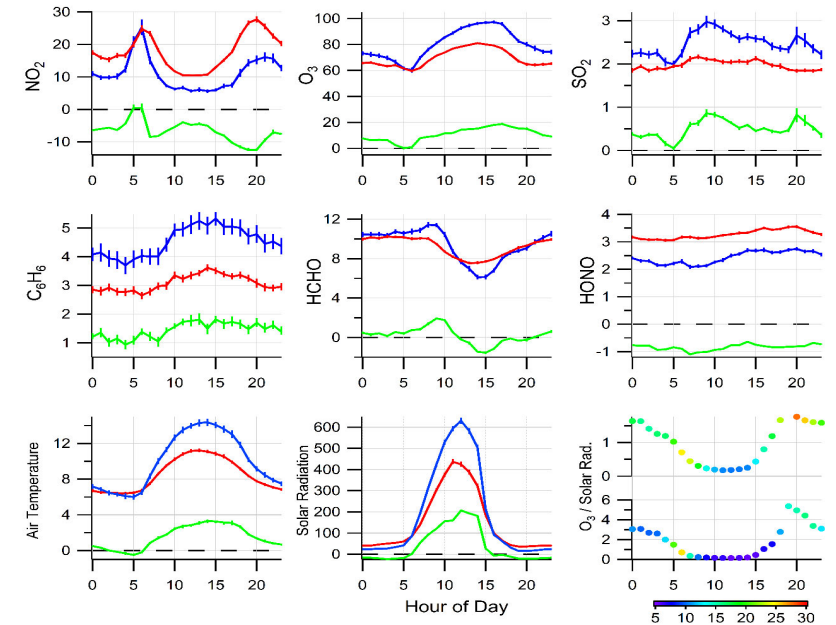
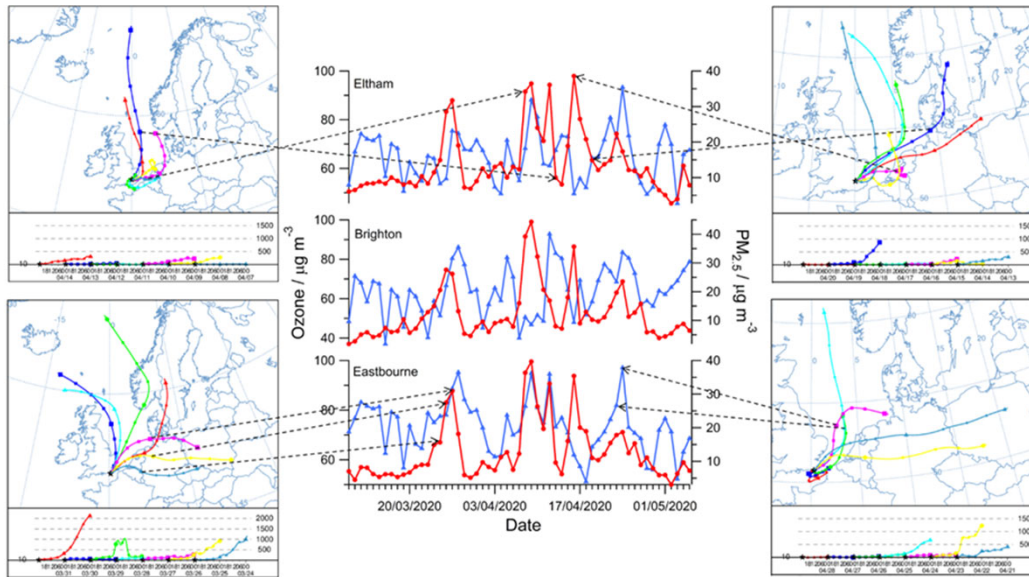


- TROPOMI NO₂ levels presented as significantly lower during lockdown (b) vs. 2019 baseline (a)
- Primary changes in centre of region (c)
- Regional average NO₂ fell by 33%

- Local relative changes in 'de-weathered' and absolute NO₂ echoed this finding (a) with Kb, UB, SB, RB levels down 14-38% (wrt 5-yr baseline)
- PM levels (b and c) were variable across sites
- O₃ levels appeared to have increased (d)



Results: Changes in detail

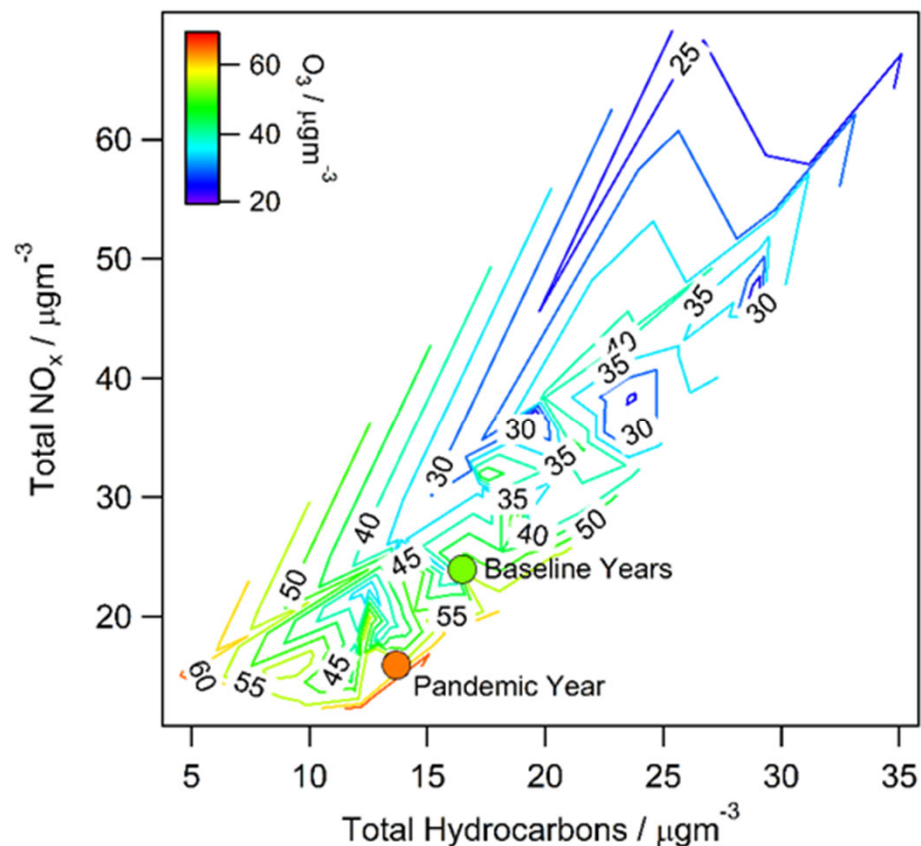


- Daily average PM_{2.5} (red) for Eltham, Brighton, Eastbourne with HYSPLIT modelling helps explain PM behaviour
- Peaks in PM correlate with the timing of mass air movements bringing pollution from North West Europe

- Average diurnal evolution of trace gases (DOAS) and met. Before (red) and during (blue) lockdown
- Similar daily patterns, but NO₂, HONO - down; O₃ (+15%), SO₂ (+25%), C₆H₆ - up; HCHO - similar; hotter and sunnier



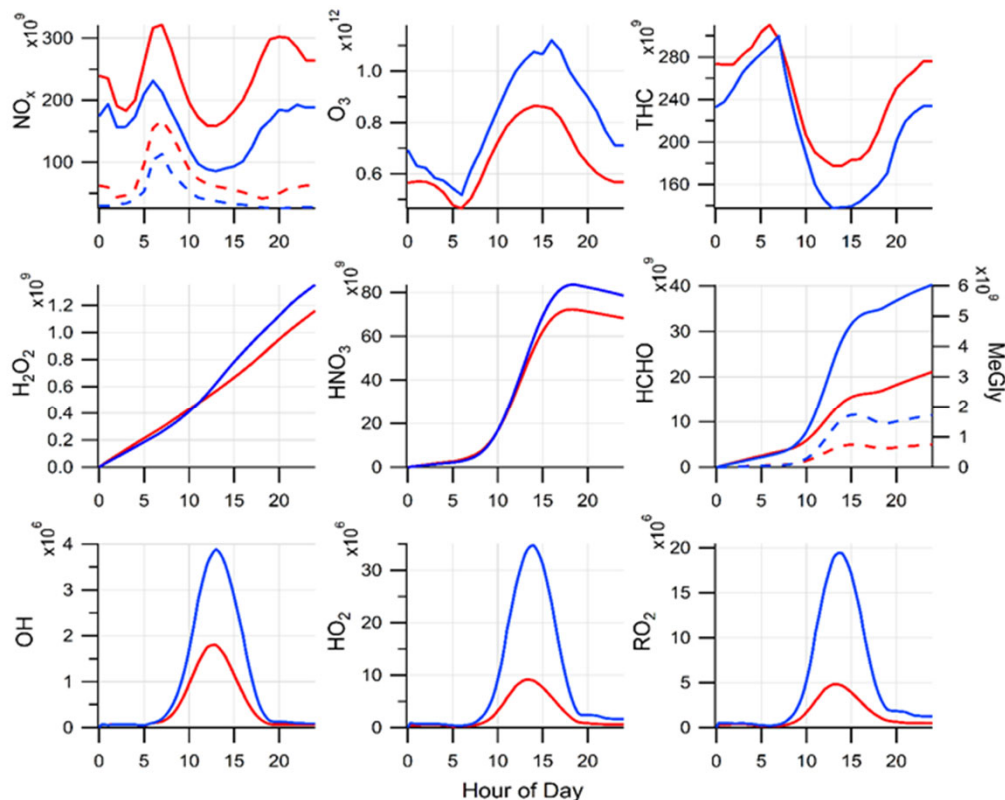
Results: Changes in chemistry



- To investigate the urban O_3 chemistry further we needed HC measurements – Eltham AHN (SB, outer London)
- Eltham: $\text{NO}_2 = -35\%$, $\text{O}_3 = +22\%$, HCs = -17%
- HCs: Aromatics = -34% , alkanes = -16% , alkenes = -6%
- NO_x -HC- O_3 relationship best visualised using a surface plot (O_3 isopleth)
- Regime: characterised by $[\text{NO}_x] > \Sigma[\text{NMHC}]$, where higher $[\text{O}_3]$ typically results from lower values of both species
- Relative positions of atmospheres before ('Baseline Years') and during lockdown ('Pandemic Year') shown
- Baseline years sit within a HC limited regime
- During lockdown, $[\text{NO}_x]$ decrease $>$ $[\text{NMHC}]$, so NMHC: NO_x increased (0.70 to 0.87). In HC limited regime (with actinic flux), this led to increase $[\text{O}_3]$



Results: Radicals and oxidative capacity



*The diurnal mean ability of the [troposphere] to oxidise trace compounds

- Question: with decreased $[\text{NO}_x]$ and increased $[\text{O}_3]$, what is the effect on radicals and oxidative capacity*?
- HCHO and methyl glyoxal values up during lockdown – more reactive atmosphere?
- Modelled OH, HO_2 and RO_2 higher during lockdown by 109, 245 and 259%
- Shift in partitioning between HO_x/RO_x during lockdown, indicative of increase in forward cycling of OH to HO_2 and RO_2 via CO and RH, and decrease in recycling of HO_2 and RO_2 to OH *via* NO
- Comparing modelled radical recycling to chain termination routes and modelled $\text{HO}_x:\text{NO}_x$, simulations suggest branching shifted toward more radical chain cycling/propagation

