USING EARTH OBSERVATIONS TO MONITOR CITY-WIDE AIR QUALITY

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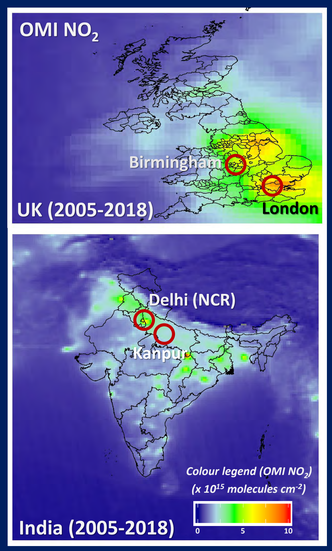
Karn Vohra (kxv745@student.bham.ac.uk)[1], Eloïse Marais[2], William Bloss[1], Peter Porter[3]

[1] School of Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham, UK;
[2] Department of Physics and Astronomy, University of Leicester, UK; [3] Birmingham City Council, Birmingham, UK

30 SECOND SUMMARY

Surface observations are sparse and inconsistent + Satellites provide long-term global observations + Validation of satellite observations with surface observations = Apply satellite observations to monitor air quality



1. INTRODUCTION

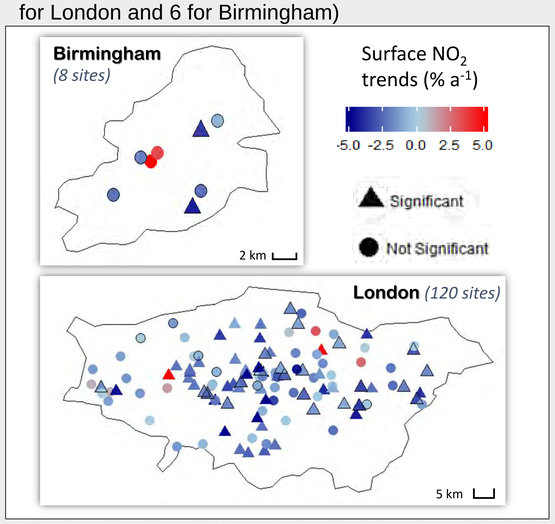
- Each year **40,000** early deaths in UK and **620,000** in India are attributed to fine particles, ozone and **NO_2** pollution; Associated health cost in UK : **£6 billion**
- Dominant NO_2 sources: diesel (UK), industry, coal combustion, vehicles, biomass burning (India)
- Here we choose 4 cities at different stages of development: **London** (developed, $PM_{2.5}$:**12** µg/m³) and **Birmingham** (urban renewal, $PM_{2.5}$:**10** µg/m³) in the UK, and **New Delhi** (semi-developed, $PM_{2.5}$:**143** µg/m³) and **Kanpur** (developing, $PM_{2.5}$:**173** µg/m³) in India
- Space-based instruments provide long-term (2005-2017) observations of NO_2 to assess the effect of rapid development and policy on air quality; we validate and use satellite observations to assess air quality in London and Birmingham

2. METHODOLOGY

- Validate satellite observations of NO_2 from the ***Ozone Monitoring Instrument (OMI)*** on-board **NASA's Aura satellite** with **DEFRA, Birmingham City Council** and **London Air Quality Network** ground-based observations
- Quantify the long-term (2005-2017) trend in OMI NO_2
- Compare OMI NO_2 levels and trends for select cities in the UK and India

3. SURFACE MONITORING OF NO_2

- Dense but periodic network of 120 monitoring sites in Greater London
- Sparse and periodic network of 8 sites in Birmingham
- Outlined points are sites with temporal overlap that we use to compare to OMI NO_2 tropospheric columns (28 for London and 6 for Birmingham)

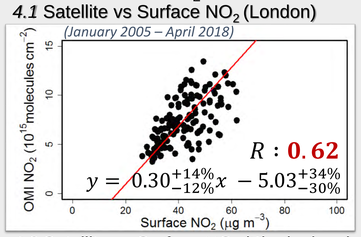


3.1 **Trends and locations of NO_2 monitoring sites in London and Birmingham**

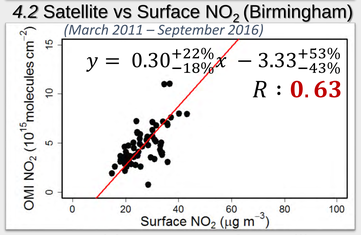
4. VALIDATION OF SATELLITE OBSERVATIONS

- Assess temporal consistency between monthly means of satellite and surface NO_2 for the UK cities

4.1 Satellite vs Surface NO_2 (London)



4.2 Satellite vs Surface NO_2 (Birmingham)

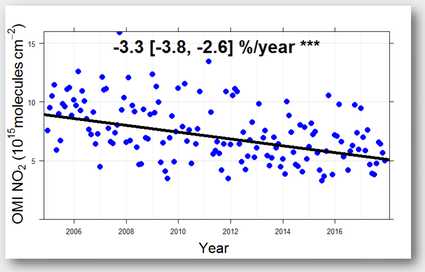


- Consistent monthly means of satellite and ground-based NO_2 for London and Birmingham give us confidence to apply satellite observations to monitor air quality for cities in UK

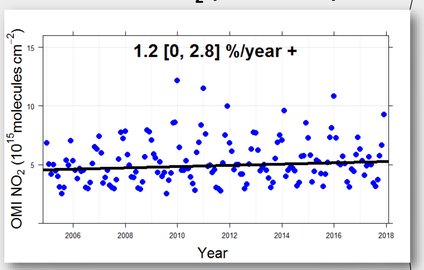
5. TRENDS IN OMI NO_2 IN UK AND IN INDIA

- We observe linear trends in monthly means of OMI NO_2 in the target cities

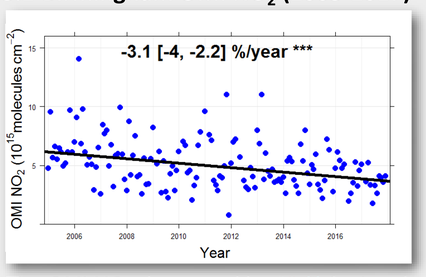
5.1 **London OMI NO_2 (2005-2017)**



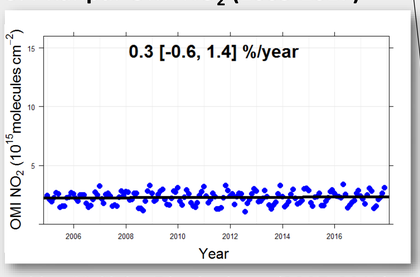
5.3 **Delhi OMI NO_2 (2005-2017)**



5.2 **Birmingham OMI NO_2 (2005-2017)**



5.4 **Kanpur OMI NO_2 (2005-2017)**

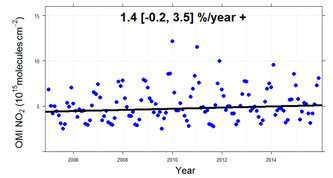


- OMI NO_2 decreased by **43 %** for London and by **40 %** for Birmingham (2005-2017)
- Significant increase (**15 %**) in OMI NO_2 levels in Delhi compared to no significant change in Kanpur for 2005-2017
- OMI NO_2 levels are similar now over London and Delhi

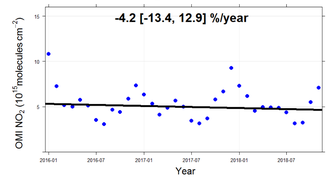
Effect of policy in place for Delhi

- New emission targets announced in December 2015

5.3.1 **Delhi OMI NO_2 (2005-2015)**



5.3.2 **Delhi OMI NO_2 (2016-2018#)**



- Decline in OMI NO_2 observed from 2016; but trend not significant

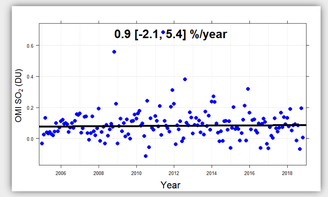
- Trends plotted till October 2018

Legend
*** : *p-value* < 0.001
** : *p-value* < 0.01
* : *p-value* < 0.5
+ : *p-value* < 0.1

6. TRENDS IN OMI SO_2 IN DELHI

- SO_2 is a precursor of sulfate, a large and often dominant component of $PM_{2.5}$
- OMI SO_2 has low signal-to-noise
- SO_2 is only detected with OMI over Delhi
- Increase in SO_2 is 0.9 % per year, but not significant

6.1 **Trends in Delhi OMI SO_2 (2005-2018)**



7. DISCUSSION

- Our work shows that NO_2 concentrations and NO_x precursor emissions in UK cities have decreased by *3.1-3.3* % per year. This is less than the UK-wide decrease in NO_x emissions from the national bottom-up emission inventory (*3.9* % per year), and, for London, almost double the decline obtained with the surface network (*1.8* % per year)
- Annual trends in OMI NO_2 for Delhi and Kanpur from 2005 to 2015 are comparable to Ul-Haq et al., 2015 (*2.1 %* for Delhi and *0.2 %* for Kanpur)

8. NEXT STEPS

- Validate satellite-based NO_2 observations for **New Delhi** and **Kanpur**
- Evaluate existing **air quality models** using satellite observations
- Interpret **NO_x emission** trends with a chemical transport model
- Extend analysis to other compounds visible from space: ammonia, aerosol optical depth (AOD) as a proxy for $PM_{2.5}$, and formaldehyde as a proxy for non-methane volatile organic compounds (NMVOCs)

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