Monitoring Air Pollution in Birmingham from the ground up

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1. INTRODUCTION

Why NO_2?	❑ Nitrogen dioxide (NO_2) impacts health directly and by forming ozone and fine particles ❑ NO_2 provides constraints on nitrogen oxides (NOx = NO + NO_2) emissions. ❑ UK Air Quality Strategy objectives are to limit NO_2 annual mean to 40 µg m^{-3}
Why Birmingham?	❑ Birmingham, a post-industrial city undergoing urban renewal has been exceeding the annual mean limit for NO_2 across 3 locations over the last 5 years ❑ Extensive research on understanding sources and temporal changes in air pollution in Birmingham can guide interpretation of the satellite observations
Why satellite observations?	❑ Instruments on-board satellites measure air pollutants ❑ These provide complete coverage of cities over long time periods (2005-2018)
Why now?	❑ Failure of Euro vehicle emission standards for diesel vehicles ❑ High mortality rate due to air pollution ❑ Effective mitigation strategies will take time to be implemented

2. METHODOLOGY

- ❑ Surface monitoring of NO_2 using chemiluminescence analyzers and satellite observations using NASA Aura's Ozone Monitoring Instrument (OMI)
- ❑ Sampled the surface observations at 12h00-15h00, entered around the satellite overpass (13h30 local time)
- ❑ Satellite data sampled over Birmingham
- ❑ Trends analysis for both surface and satellite observations using Theil-Sen estimator for overlapping period (Mar'11-Sep'16) based on data availability
- ❑ Spatial correlation across the monitoring sites to assess homogeneity of NO_2 in Birmingham to derive a city level NO_2 concentration
- ❑ Asses temporal consistency between surface and satellite NO_2

3. TRENDS IN NO_2

- Tropospheric column NO_2 has decreased by 39% over the last decade
- Decline in OMI NO_2 becomes very significant over the long OMI record (2005-2017) and is 3.4% a^{-1}

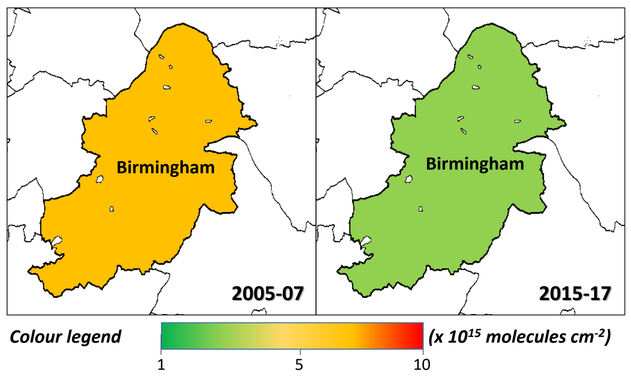
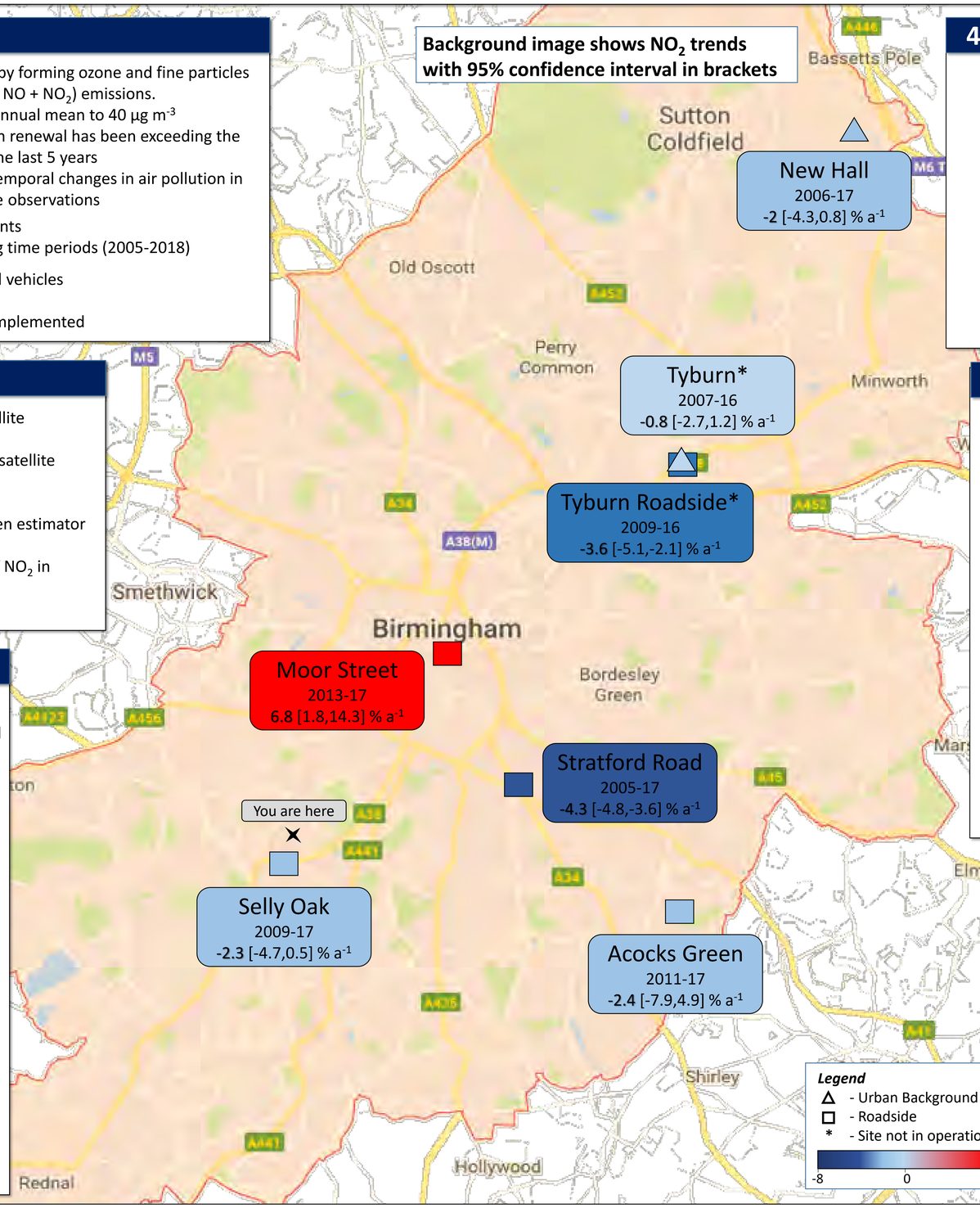


Figure 1 Satellite data coverage for Birmingham

- Sites are spatially correlated (R > 0.55) and so are combined to obtain a representative city average NO_2
- Surface NO_2 decreases by 3.1% a^{-1} from 2011 to 2016



4. VALIDATION OF SATELLITE OBSERVATIONS

- OMI NO_2 gives steeper decline of 4.1% a^{-1} from 2011 to 2016 compared to surface NO_2
- Surface and OMI NO_2 are temporally correlated (R = 0.69)

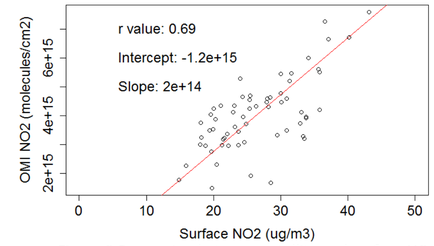


Figure 2 Regression between satellite and surface NO_2

5. DISCUSSION

- Six monitoring stations follow a decreasing trend; Moor Street is undergoing a lot of development and follows an increasing trend
- All trends are not significant due to large temporal variability and a short period of overlap
- Decline in OMI NO_2 becomes very significant (p-value < 0.001) over the long OMI record (2005-2017) and is 3.4% a^{-1} , similar to the reported UK-wide decrease in NO_x emissions of 3.9% a^{-1}
- Other locations in UK show a less steep trend in surface NO_2 from 2005-2016 (decline in surface NO_2: 1.4% a^{-1} in London, 0.9% a^{-1} in Glasgow and 2.3% a^{-1} in Cambridge)
- A negative intercept in figure 2 is because surface instruments are close to pollutions sources, whereas the satellite covers the full extent of Birmingham
- We estimate that annual mean tropospheric column NO_2 equivalent to the EU standard and WHO guideline of 40 µg m^{-3} is 6×10^{15} molecules cm^{-2}
- This could be used to assess whether city-wide NO_2 concentrations exceed levels safe for human health in cities that lack surface monitoring networks

6. NEXT STEPS

- ➢ Similar validation to be completed for satellite observations of other air pollutants namely ozone, sulfur dioxide, carbon monoxide and particulate matter in Birmingham
- ➢ Apply this approach to monitor rapidly developing cities like New Delhi, Kathmandu, Jakarta, Ontisha, Johannesburg and Sao Paulo

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30 SECOND SUMMARY

- ❖ Air pollution has adverse effects on human health and vegetation
- ❖ Surface observations of NO_2 in Birmingham show a declining trend of 1.5-4.2% a^{-1} (except Moor Street) and are spatially correlated (R > 0.55) to give a city-wide average NO_2 concentration (decline of 3.1 % a^{-1})
- ❖ We show that monthly average surface and satellite observations of NO_2 are consistent; thus satellite observations can be used to monitor monthly changes in NO_2 in cities
- ❖ We suggest an annual mean threshold of tropospheric column NO_2 so that satellite observations can be used to assess whether air quality in cities is hazardous to health

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