

# TRENDS IN CITY-WIDE AIR QUALITY AS OBSERVED FROM SPACE

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## 1. INTRODUCTION

- Each year **40,000** early deaths in UK and **620,000** in India are attributed to **fine particles**, ozone and **NO<sub>2</sub>** pollution; Associated health cost in UK : **£6 billion**
- Here we choose 4 cities at different stages of development: **London** (developed, PM<sub>2.5</sub>:**12** µg/m<sup>3</sup>) and **Birmingham** (urban renewal, PM<sub>2.5</sub>:**10** µg/m<sup>3</sup>) in the UK, and **New Delhi** (semi-developed, PM<sub>2.5</sub>:**143** µg/m<sup>3</sup>) and **Kanpur** (developing, PM<sub>2.5</sub>:**173** µg/m<sup>3</sup>) in India
- Space-based instruments provide long-term observations of air pollutants to assess the effect of rapid development and policy on air quality; we validate and use satellite observations to assess air quality in the 4 target cities in the UK and India

## 2. METHODOLOGY

- Validate satellite observations of NO<sub>2</sub> 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 and validate satellite observations of NH<sub>3</sub> from the **Infrared Atmospheric Sounding Interferometer (IASI)** on-board **Metop-A satellite** with ground observations from **EMEP's supersites** in the UK
- Quantify the long-term trend in satellite observations of NO<sub>2</sub>, NH<sub>3</sub>, HCHO (proxy for NMVOCs) and AOD (proxy for PM<sub>2.5</sub>) for the target cities in the UK and India

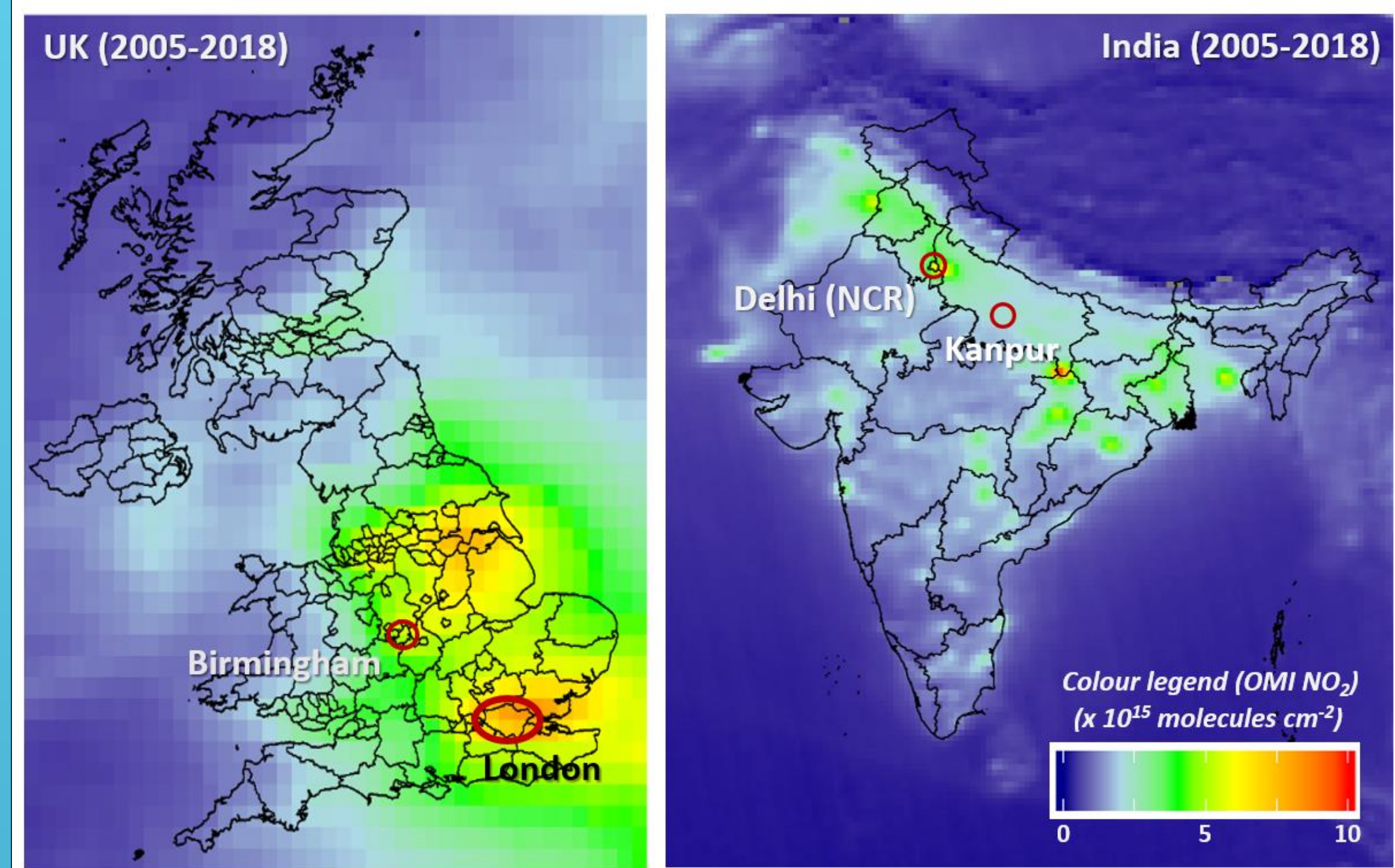


Figure 1. Maps of the UK and India showing hotspots of NO<sub>2</sub> pollution as observed from space and locations of the target cities in the two countries

## 3. SURFACE MONITORING OF NO<sub>2</sub>

- 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<sub>2</sub> tropospheric columns (46 for London and 6 for Birmingham)

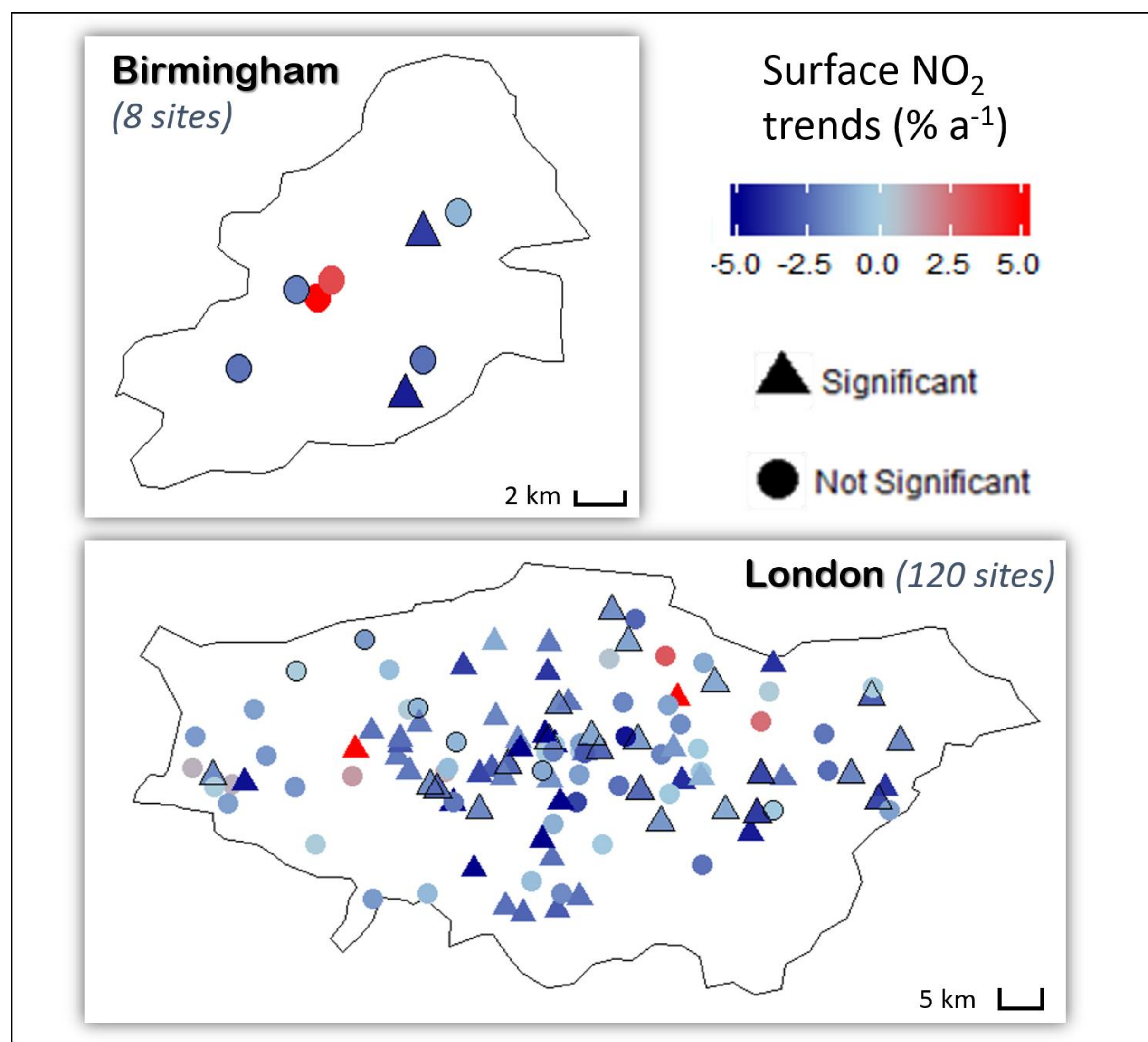


Figure 2. Trends and locations of NO<sub>2</sub> monitoring sites in London and Birmingham

## 4. VALIDATION OF SATELLITE OBSERVATIONS

- Assessed temporal consistency between monthly means of satellite and surface NO<sub>2</sub> for London and Birmingham; For London, R = 0.51 for all months excluding DJF (shown alongside) and R = 0.33 for DJF only and for Birmingham, R = 0.71 for all months excluding DJF and R = 0.69 for DJF only
- Satellite-based NH<sub>3</sub> assessed against the surface observations from rural supersites in the UK; R = 0.60 for Harwell (shown alongside), R = 0.79 for Chilbolton Observatory, R = 0.46 for Auchencorth Moss
- Consistent monthly means of satellite and ground-based NO<sub>2</sub> and NH<sub>3</sub> give us confidence to apply satellite observations to monitor air quality for cities in UK

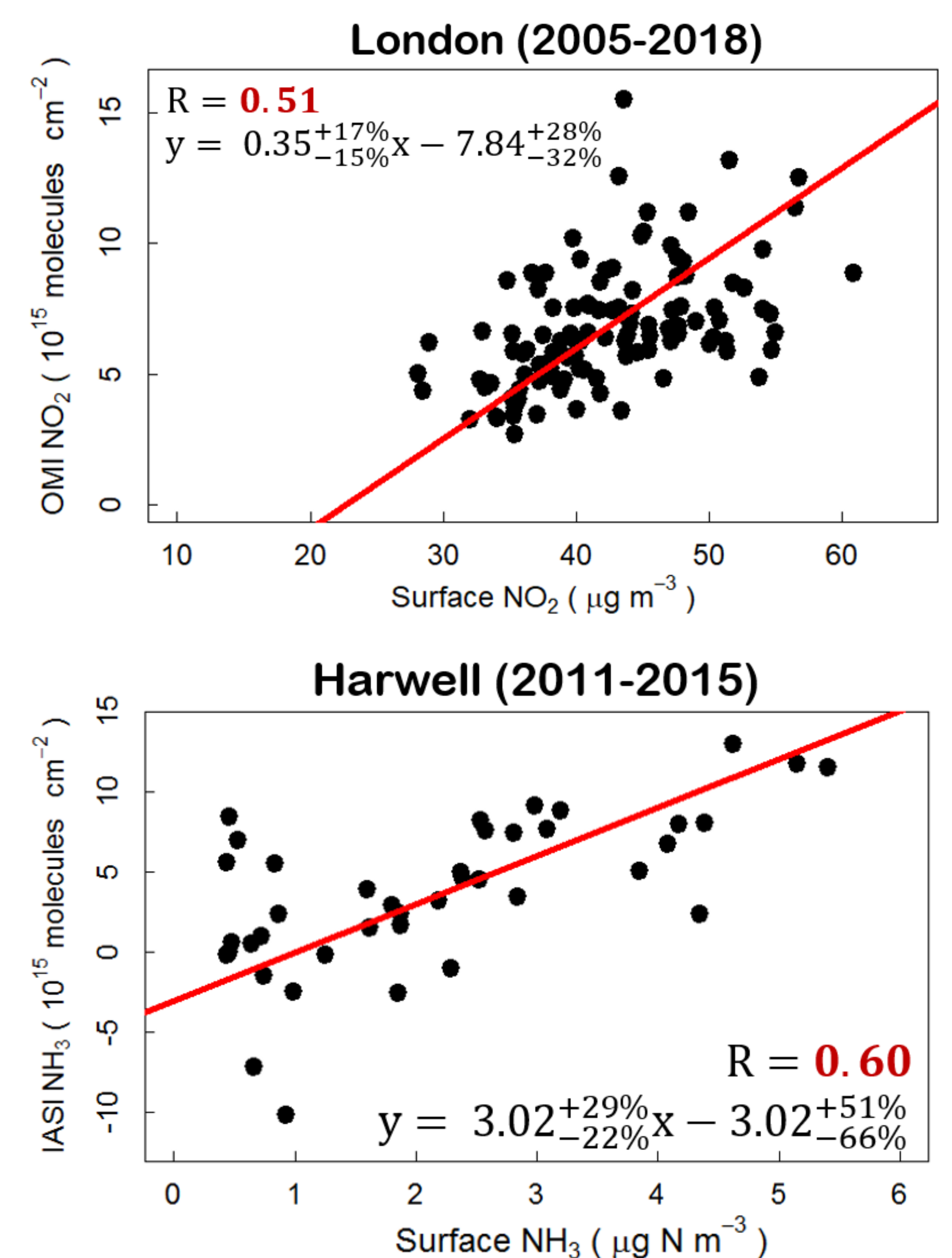


Figure 3. Evaluation of monthly means of satellite column against ground observations – NO<sub>2</sub> in London for non-winter (top) and NH<sub>3</sub> in Harwell (bottom)

## 5. TRENDS IN AIR QUALITY IN THE UK AND IN INDIA

- We observe linear trends in monthly means of OMI NO<sub>2</sub>, IASI NH<sub>3</sub>, OMI HCHO and Moderate Resolution Imaging Spectroradiometer (MODIS) AOD in the target cities
- Air quality is improving in the UK cities (significant decrease in NO<sub>x</sub> emissions; 35 % in 2005-2018) while it is degrading in the cities in India (significant increase in PM<sub>2.5</sub> emissions; 36-44 % in 2005-2018)

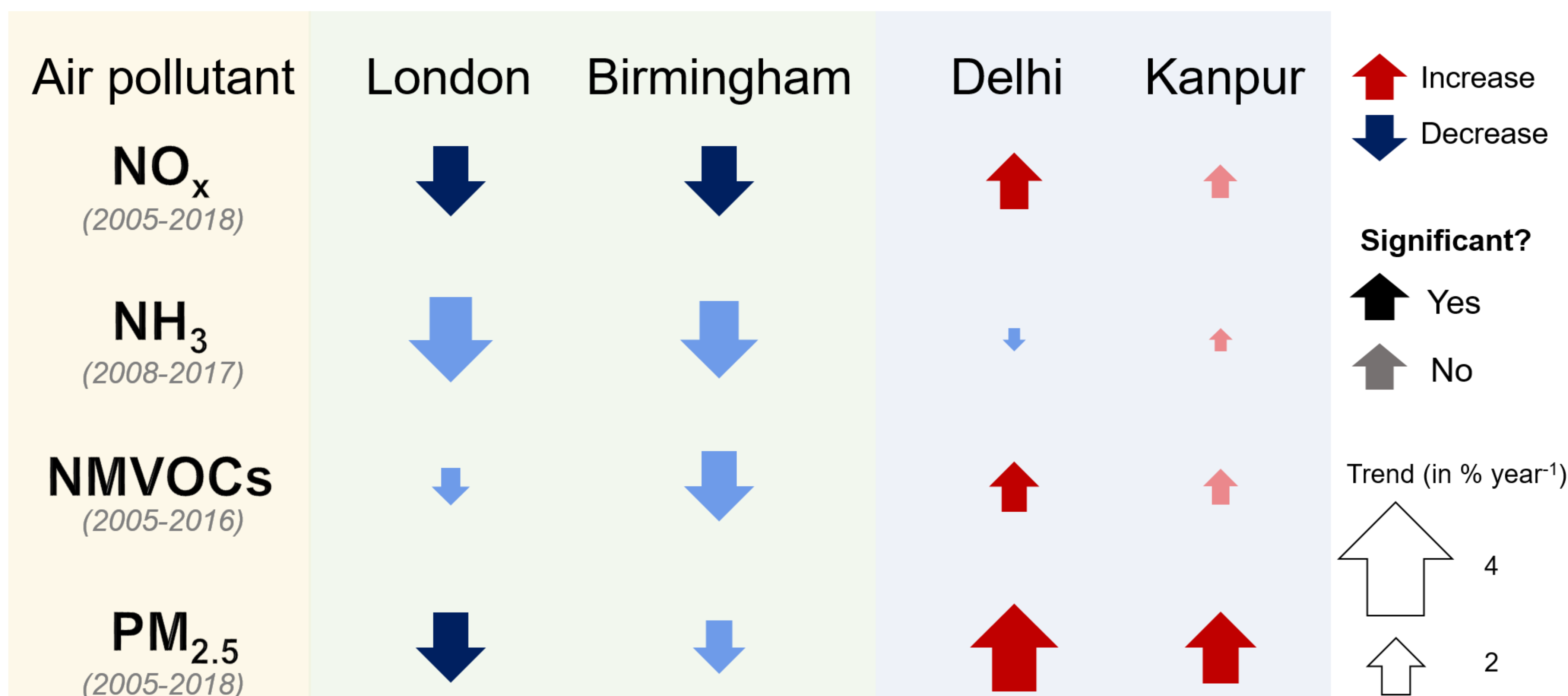


Figure 4. Long-term trends of satellite observations of air pollutants for select cities in the UK and India

## 6. NEXT STEPS

- Validate satellite measurements of HCHO and AOD against available surface observations of NMVOCs and PM<sub>2.5</sub>
- Evaluate existing air quality models using satellite observations

## 5-SECOND SUMMARY

The direction of trends in air quality for all the select cities is consistent with other studies using satellite observations but the magnitudes are different owing to the differences in instruments and time periods

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