Supporting information for

TROPOMI NO_2 for urban and polluted areas globally from 2019 to 2024

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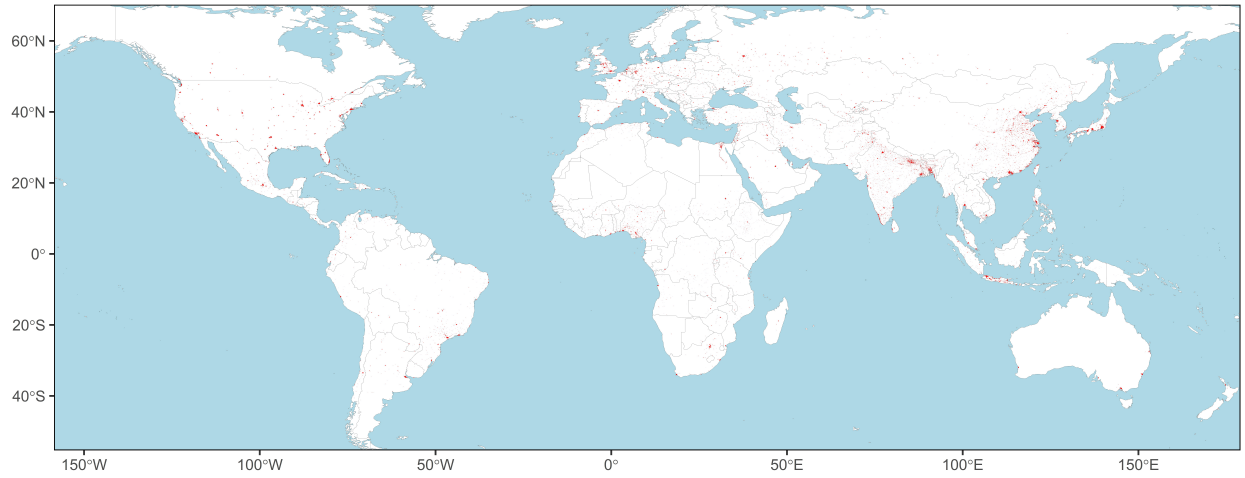


Figure S1: Spatial representation of all urban clusters included in the 2023a version of GHS-SMOD (red polygons).

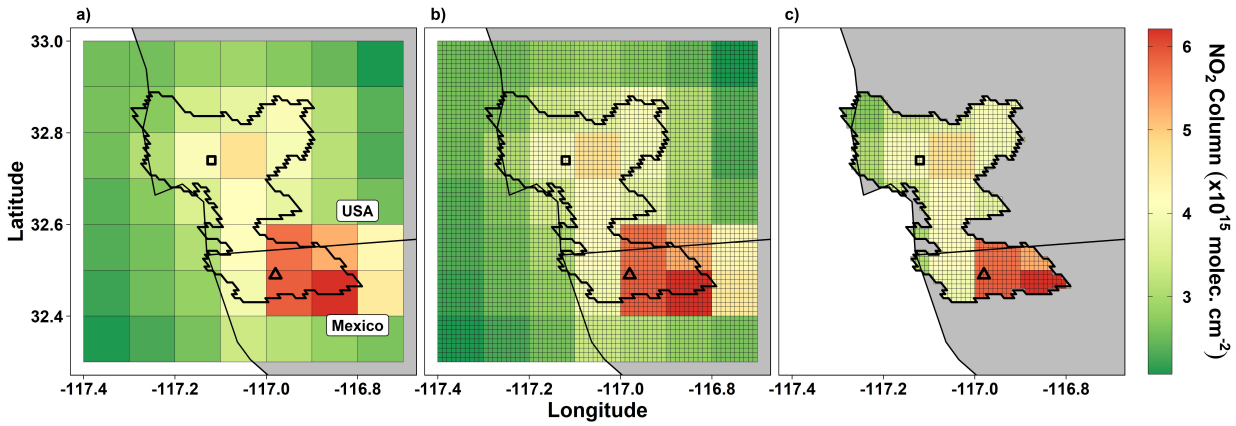


Figure S2: Spatial representation of one urban cluster boundary from the version 2023a GHS-SMOD dataset (black outline) that encompasses both San Diego, CA, USA (black square) and Tijuana, Mexico (black triangle). Colors show TROPOMI tropospheric NO_2 column concentrations (a) at the 0.1 x 0.1 degree spatial resolution of the oversampled level 3 product, (b) after disaggregating to 0.01 x 0.01 degrees and (c) after subsetting for grid cells within the urban cluster boundary, which are subsequently used to determine average NO_2 concentrations for each urban cluster.

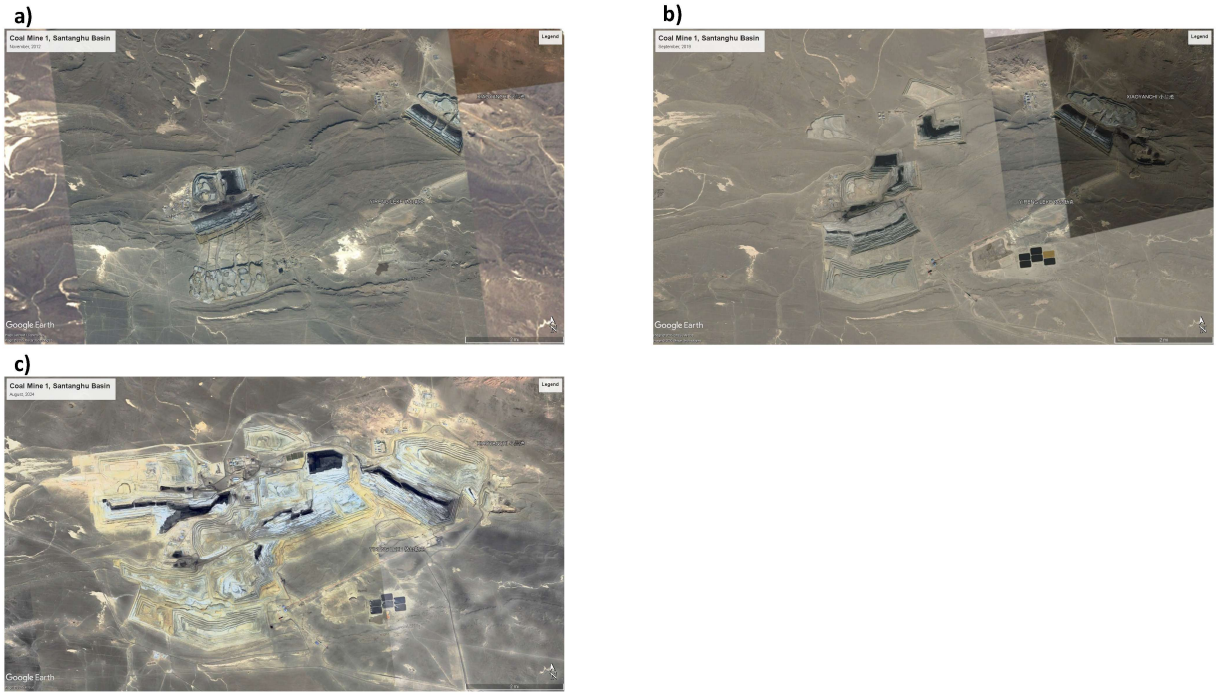


Figure S3: Satellite imagery showing the expansion of mining operations at a site in the Santanghu Basin in Xinjiang Province, China. Panels show the mine in (a) 2012, (b) 2019 and (c) 2024. Scale on the bottom right of each panel shows distance of 2 miles on the image. © Google Earth.

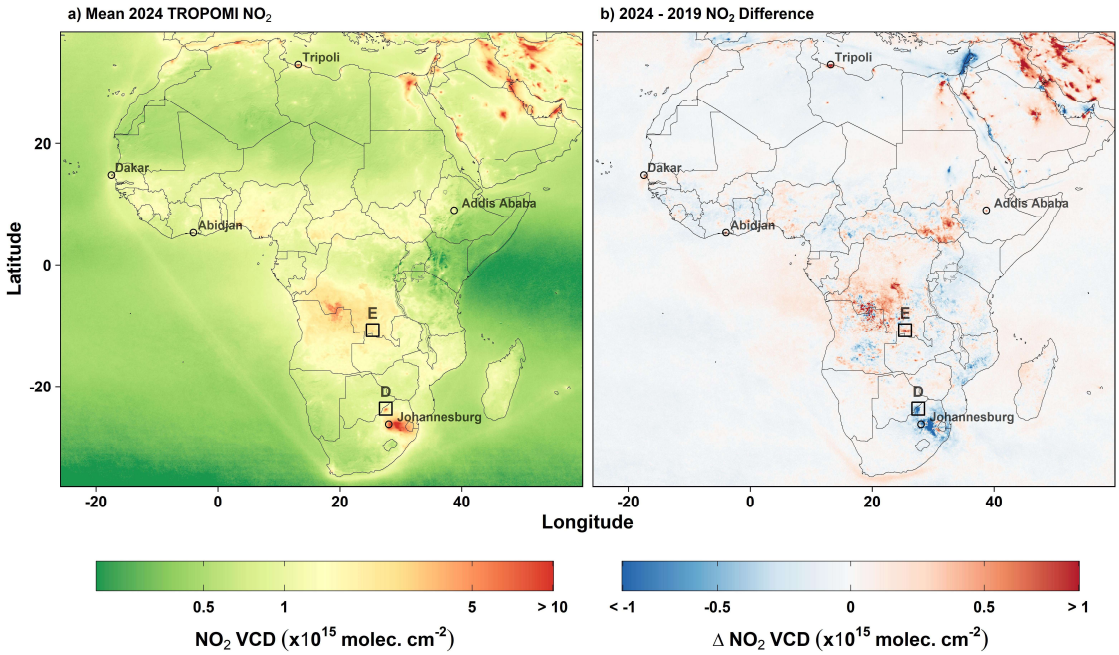


Figure S4: (a) Mean 2024 TROPOMI NO_2 VCDs and (b) relative changes in TROPOMI VCDs from 2019 to 2024, centered on Africa. Labeled black square indicates the locations of mining regions highlighted in Fig. 3 of the main manuscript.

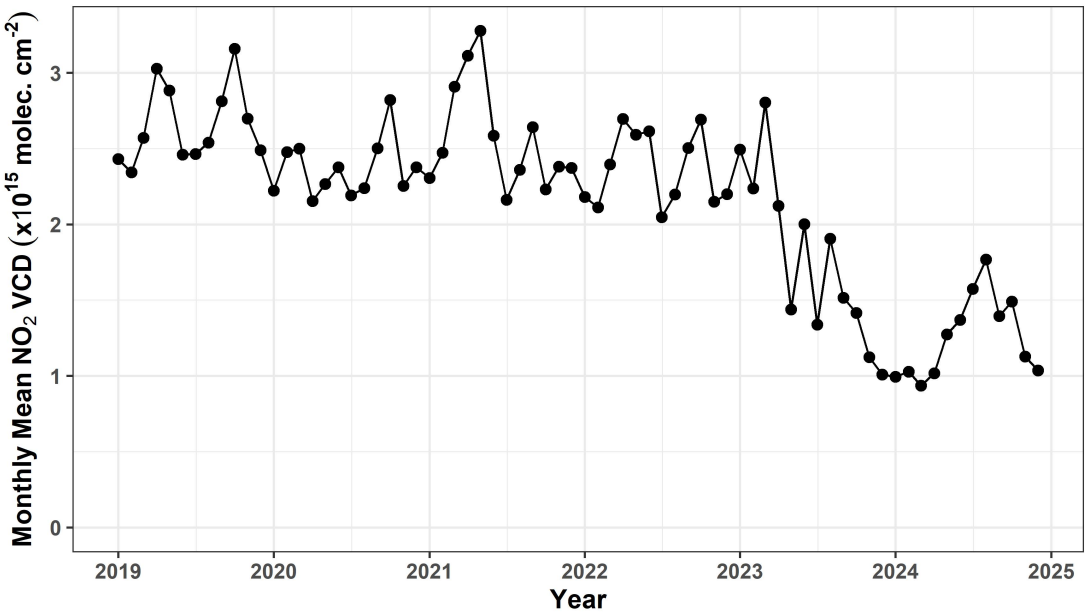


Figure S5: Monthly mean NO_2 VCD for the Khartoum, Sudan urban cluster.

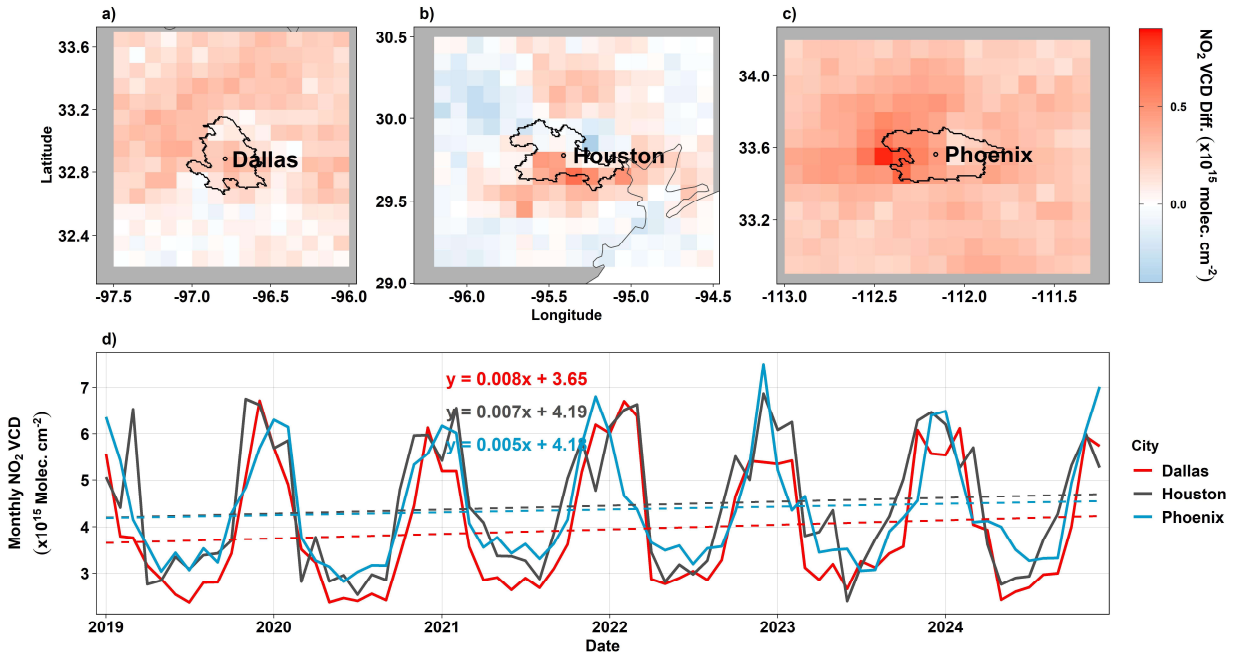


Figure S6: Absolute change in NO_2 VCD from 2019 to 2024 for three U.S. cities: (a) Dallas, Texas, (b) Houston, Texas and (c) Phoenix, Arizona. Colors in panels a-c show VCD change, thin lines show national and state borders or coastlines, and thick lines show the GHS-SMOD urban boundary. (d) Solid lines show monthly mean TROPOMI NO_2 VCD from January 2019 through December 2024, colored by city. Dashed lines show best-fit linear trends for each city, with the slope representing the change in NO_2 VCD per month, and the y-intercept representing the intercept for January, 2019. Best-fit linear equations for each city are shown in the top right of panel d.

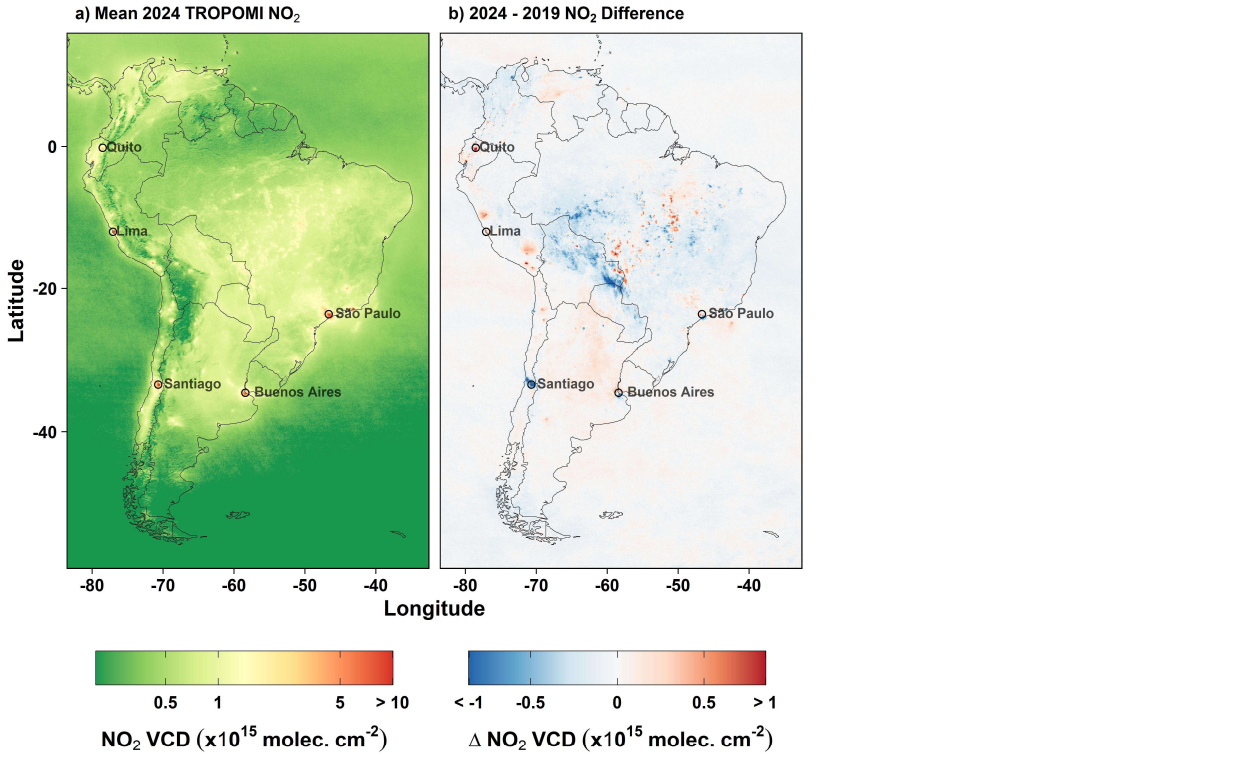


Figure S7: (a) Mean 2024 TROPOMI NO_2 VCDs and (b) relative changes in TROPOMI VCDs from 2019 to 2024, centered on South America.

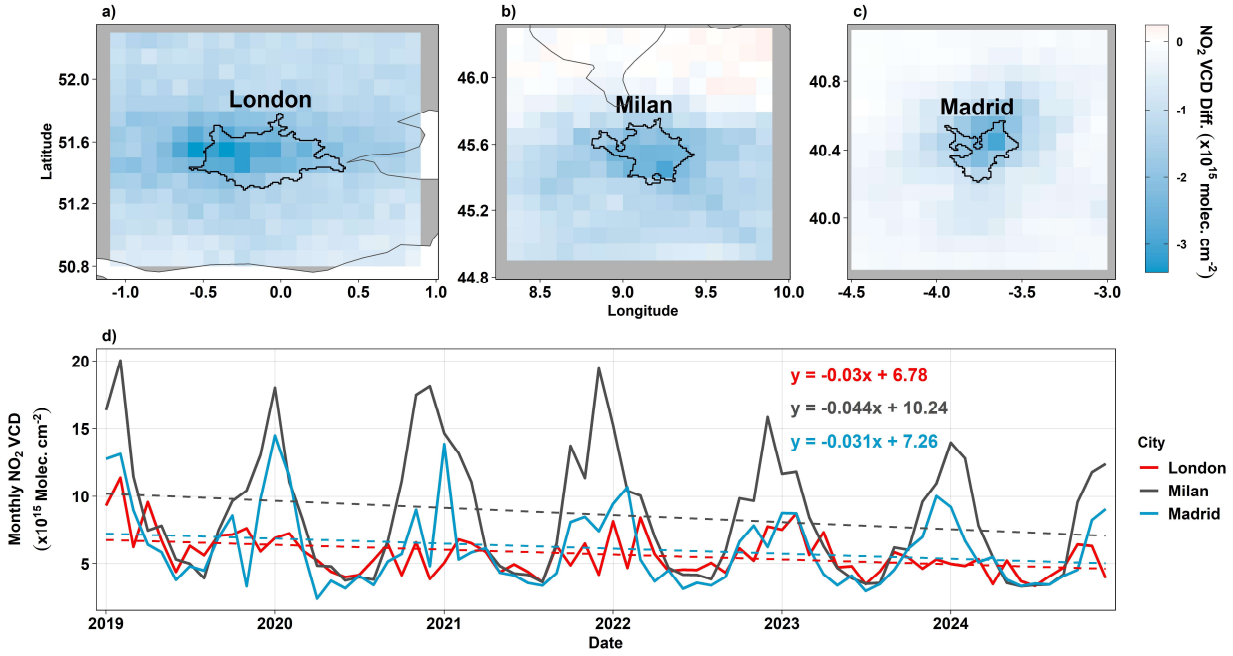


Figure S8: Same as Fig. S6, but for (a) London, (b) Milan and (c) Madrid and (d) monthly trends.

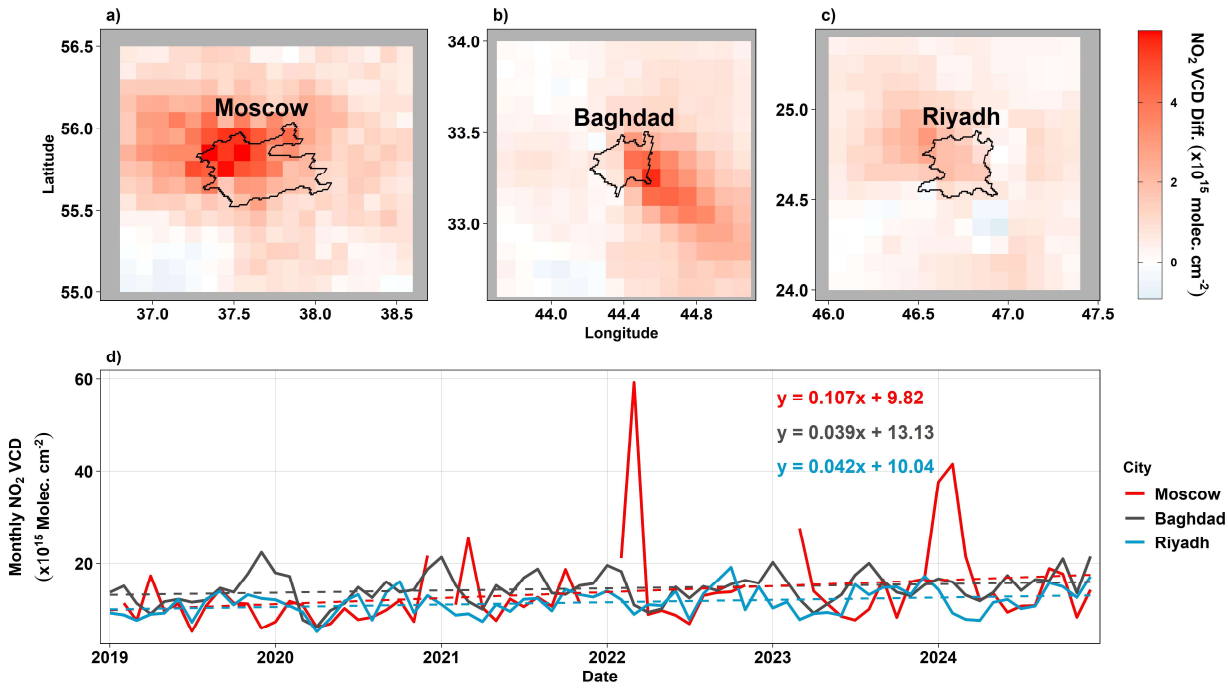


Figure S9: Same as Fig. S6, but for (a) Moscow, (b) Baghdad and (c) Riyadh and (d) monthly trends.

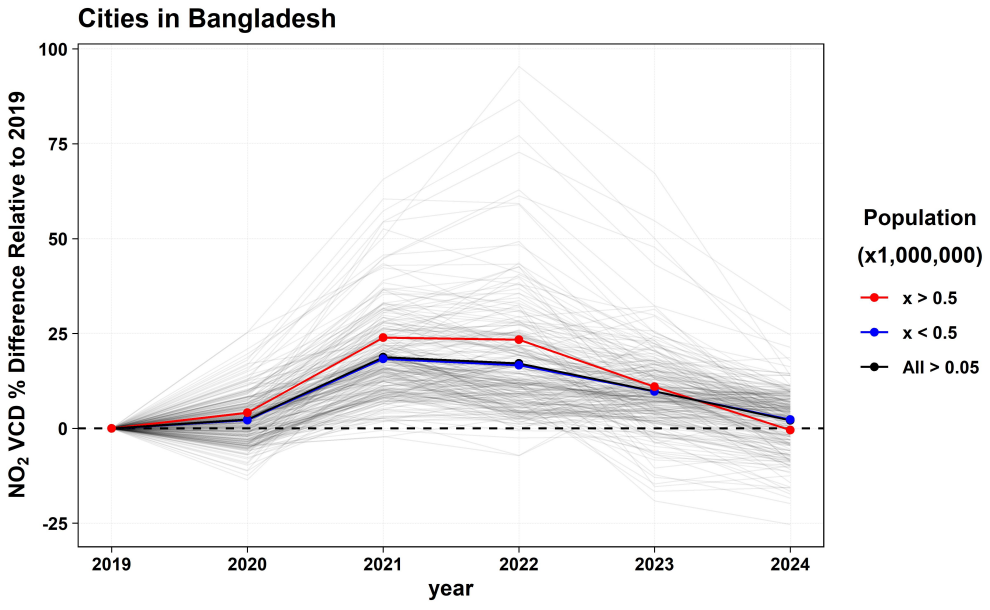


Figure S10: Annual mean TROPOMI NO_2 VCD for individual GHS-SMOD cities in Bangladesh (gray lines) and averages for all cities (black), cities with population < 500,000 (blue) and > 500,000 (red).

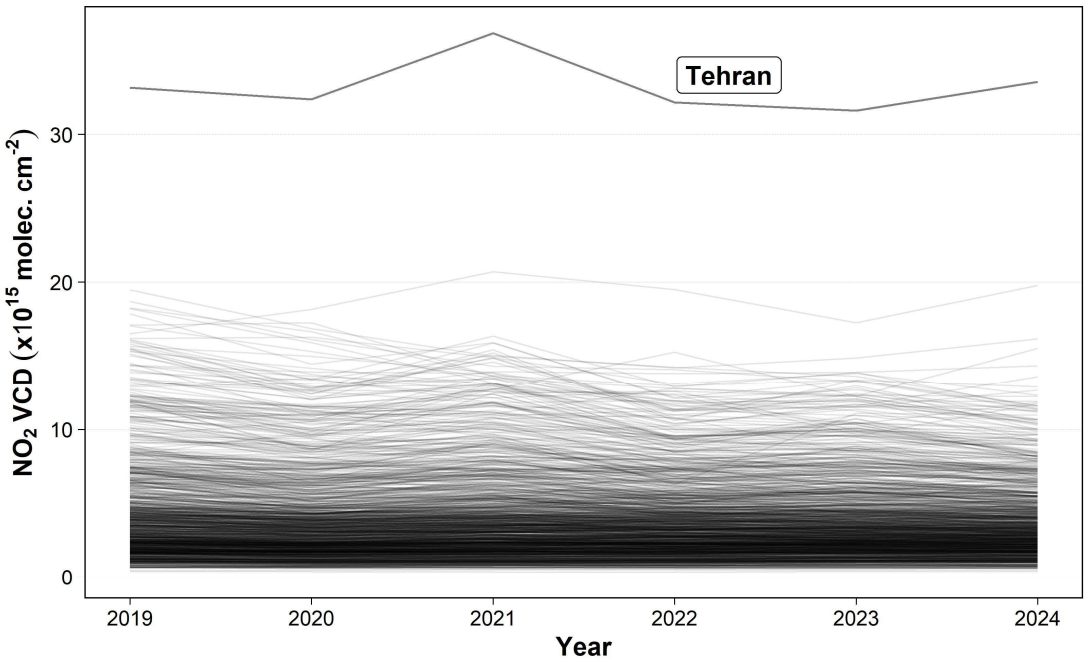


Figure S11: Annual mean TROPOMI NO_2 VCD for all GHS-SMOD urban clusters with a population greater than 500,000 (thin gray lines) and for the Tehran, Iran urban cluster (thick gray line).

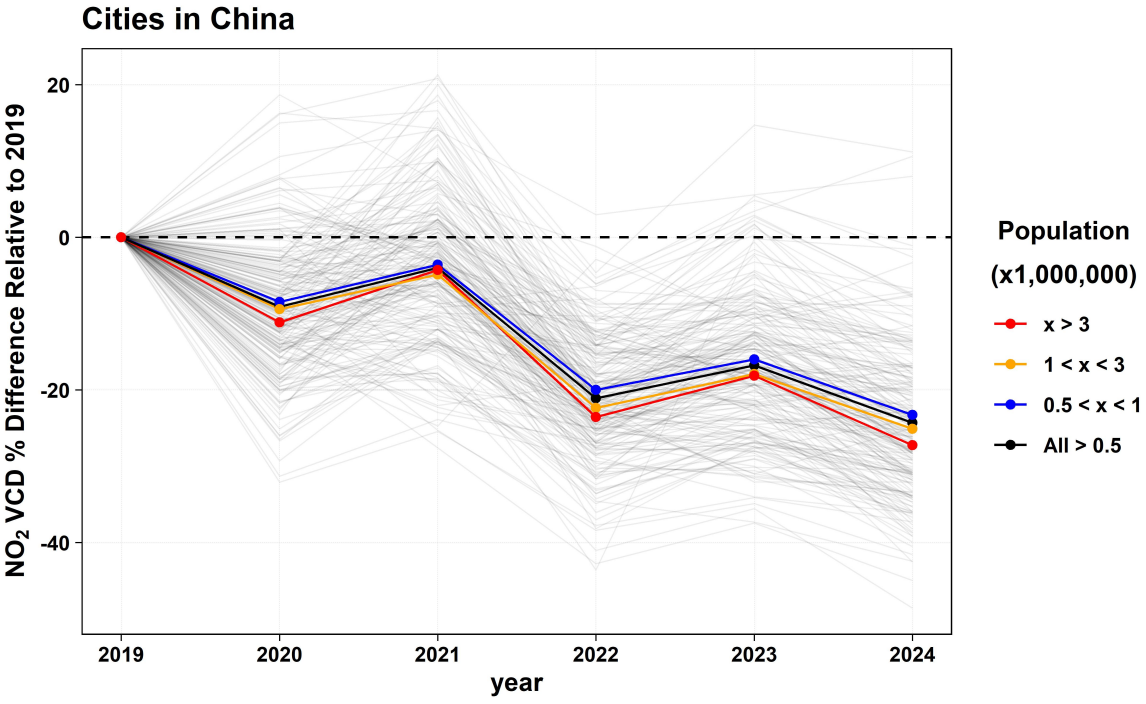


Figure S12: Annual mean TROPOMI NO_2 VCD for individual GHS-SMOD cities in China with a population greater than 500,000 (gray lines) and averages for all cities > 500,000 (black), cities with population between 500,000 and 1 million (blue), cities with population between 1 and 3 million (yellow) and cities > 3 million (red).

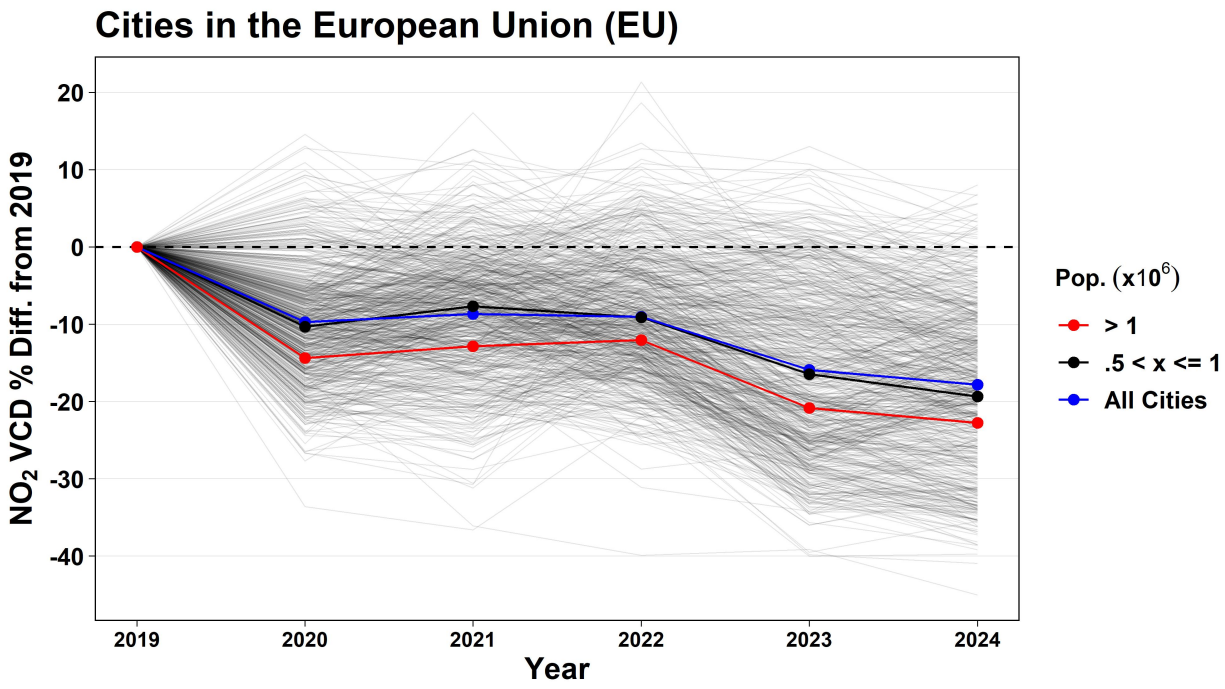
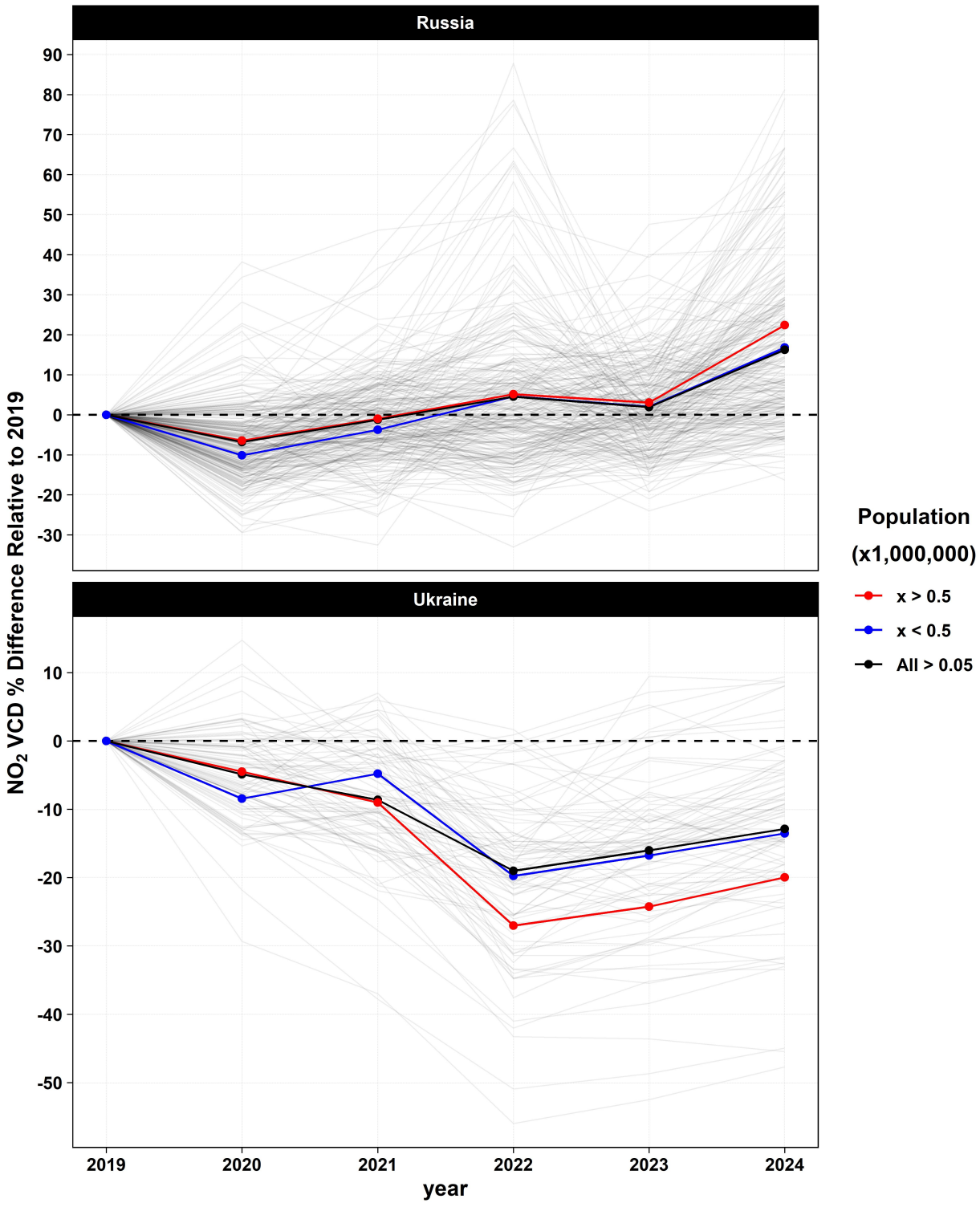


Figure S13: Annual mean TROPOMI NO_2 VCD for individual GHS-SMOD cities in the E.U. (gray lines) and averages for all cities (blue), cities with population < 1 million (black) and > 1 million (red).



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65 Figure S14: Annual mean TROPOMI NO_2 VCD for individual GHS-SMOD cities in (a) Russia and (b)
66 Ukraine (gray lines) and averages for all cities (black), cities with population < 500,000 (blue) and >
67 500,000 (red).

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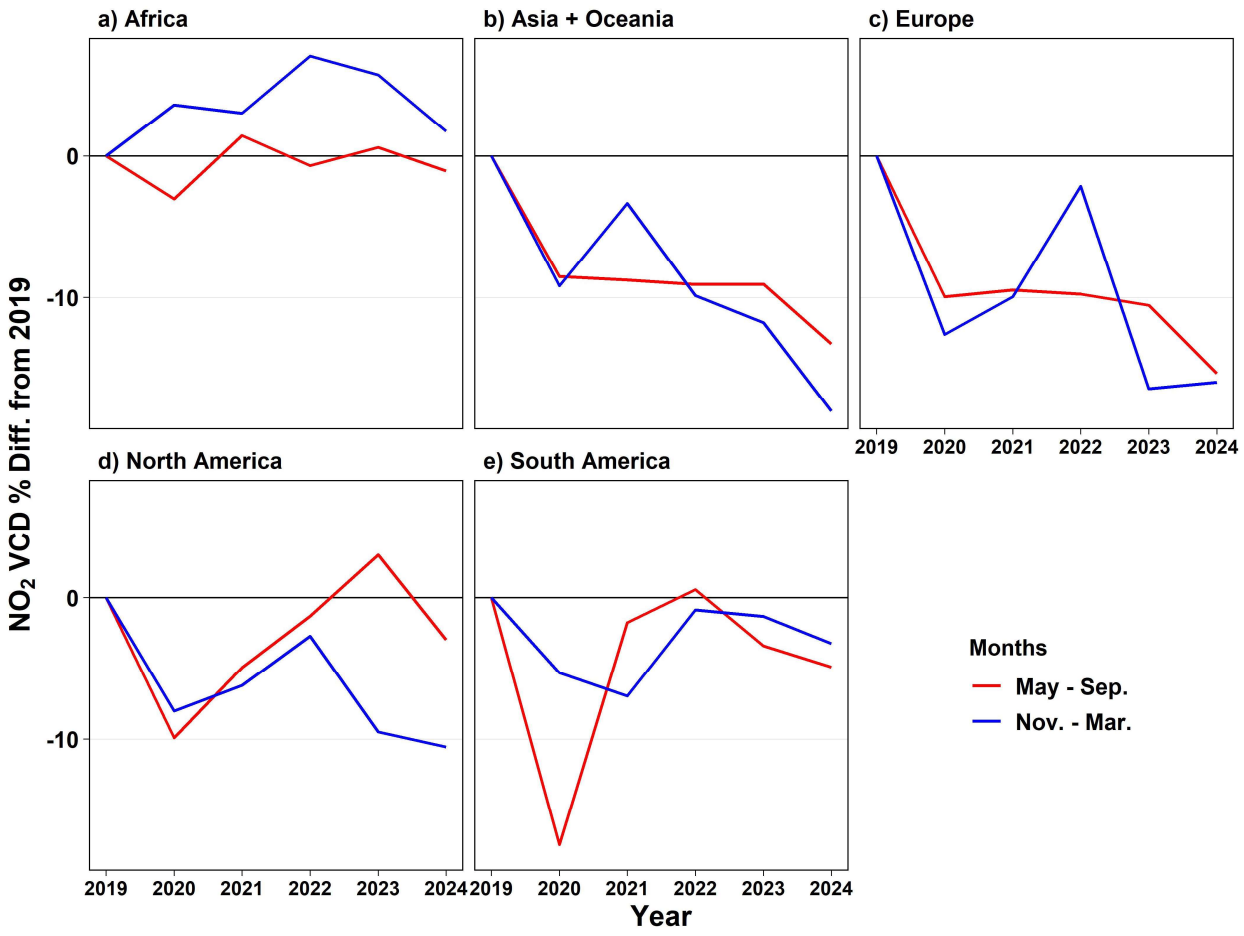

Figure S15: Relative change in urban NO_2 VCDs averaged for GHS-SMOD urban cluster from 2019 to 2024 for May – September (red lines) and November – March (blue lines) in (a) Africa, (b) Asia and Oceania, (c) Europe, (d) North America and (e) South America.