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# Impact of 2020 COVID-19 lockdowns on particulate air pollution across Europe

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Table S1. Regulated air pollutant measurement methods employed at urban sites.

| Site | $PM_{10}$ | $PM_{2.5}$ | NO | $NO_2$ | $O_3$ |
|---|---|---|---|---|---|
| Helsinki | on-line microbalance | on-line microbalance | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| Oslo | optical particle counting | optical particle counting | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| Copenhagen | on-line microbalance | on-line microbalance | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| Rotterdam | β-attenuation | β-attenuation | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| Leipzig | on-line microbalance | N/A | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| Brussels | on-line microbalance(1) | on-line microbalance(1) | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| Lille | on-line microbalance(1) | on-line microbalance(1) | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| Prague | β-attenuation | β-attenuation | chemiluminescence | chemiluminescence_ photolytic converter | UV absorption |
| Paris | on-line microbalance(1) | N/A | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| Bern | gravimetric | gravimetric | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| Milan | β-attenuation | N/A | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| Barcelona | gravimetric | gravimetric | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| Athens | gravimetric | gravimetric | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| Seville | β-attenuation | N/A | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| Granada | β-attenuation | N/A | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| Nicosia | on-line microbalance(1) | on-line microbalance(1) | chemiluminescence | chemiluminescence_ photolytic converter | UV absorption |

(1) with Filter Dynamic Measurement System®

Table S2. Regulated air pollutant measurement methods employed at regional background sites.

| Site | $PM_{10}$ | $PM_{2.5}$ | NO | $NO_2$ | $O_3$ |
|---|---|---|---|---|---|
| HYY | gravimetric | gravimetric | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| BIR | gravimetric | gravimetric | chemiluminescence | iodide impregnated glass sinter | UV absorption |
| RIS | gravimetric | gravimetric | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| CBW | β-attenuation | β-attenuation | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| MEL | gravimetric | gravimetric | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| KOS | gravimetric | gravimetric | chemiluminescence | chemiluminescence_ photolytic converter | UV absorption |
| SIR | optical particle counting | optical particle counting | chemiluminescence | chemiluminescence_ photolytic converter | UV absorption |
| PAY | gravimetric | gravimetric | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| IPR | on-line microbalance(1) | N/A | chemiluminescence | chemiluminescence_ photolytic converter | UV absorption |
| MSY | gravimetric | gravimetric | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| ARN | β-attenuation | N/A | chemiluminescence | chemiluminescence_ Mo converter | UV absorption |
| CYP | gravimetric | gravimetric | chemiluminescence | chemiluminescence_ photolytic converter | UV absorption |

(1) with Filter Dynamic Measurement System ®

Table S3. Multi-wavelength aerosol light absorption and particle number size distribution instruments employed at urban and regional background sites.

| Site | Time period | multi-WL light absorption[1] | | particle number size distribution | | |
|---|---|---|---|---|---|---|
| | | instrument type[1] | WL range (nm) | instrument type[2] | lower bound (nm) | upper bound (nm) |
| Helsinki | 2017-2020 | N/A | N/A | DMPS | 3 | 794 |
| Oslo | 2017-2020 | AE33 | 370 - 950 | N/A | N/A | N/A |
| Copenhagen | 2017-2020 | N/A | N/A | SMPS | 40 | 478 |
| Rotterdam | 2019-2020 | N/A | N/A | N/A | N/A | N/A |
| Leipzig | 2017-2020 | N/A | N/A | SMPS | 10 | 800 |
| Brussels | 2017-2020 | AE31 | 370 - 950 | N/A | N/A | N/A |
| Lille | 2017-2020 | AE33 | 370 - 950 | SMPS | 16 | 800 |
| Bern | 2018-2020 | AE33[3] | 370 - 950 | N/A | N/A | N/A |
| Milan | 2019-2020 | N/A | N/A | N/A | N/A | N/A |
| Barcelona | 2017-2020 | AE33 | 370 - 950 | SMPS | 11 | 478 |
| Athens | 2017-2020 | AE33 | 370 - 950 | SMPS | 10 | 550 |
| Granada | 2017-2020 | N/A | N/A | SMPS | 11 | 496 |
| Nicosia | 2017-2020 | AE33 | 370 - 950 | N/A | N/A | N/A |
| HYY | 2017-2020 | CLAP | 467 - 652 | DMPS | 3 | 1000 |
| BIR | 2017-2020 | PSAP | 470 - 660 | DMPS | 10 | 800 |
| RIS | 2017-2020 | N/A | N/A | SMPS | 40 | 478 |
| MEL | 2017-2020 | N/A | N/A | SMPS | 5 | 800 |
| KOS | 2017-2020 | AE33 | 470 - 660 | SMPS | 9 | 845 |
| SIR | 2017-2020 | AE33 | 370 - 950 | N/A | N/A | N/A |
| PAY | 2017-2020 | AE33 | 370 - 950 | N/A | N/A | N/A |
| IPR | 2017-2020 | AE31 | 370 - 950 | DMPS | 10 | 800 |
| MSY | 2017-2020 | AE33 | 370 - 950 | SMPS | 9 | 856 |
| ARN | 2019-2020 | CLAP | 467 - 652 | SMPS | 14 | 673 |

1: AE = aethalometer®, CLAP = continuous light absorption photometer, PSAP = particle soot absorption photometer

2: DMPS = differential mobility particle sizer, SMPS = scanning mobility particle sizer

3: AE31 until November 2018

Table S4. Coefficients of determination of the linear regression between daily CAMS ensemble forecast and observation data in February-May 2019 across the sites considered in this study. Coefficients ≥ 0.5 (1 significant digit) in bold.

| | $NO_2$ | NO | $O_3$ | $PM_{10}$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| Helsinki | **0.46** | 0.25 | 0.32 | 0.29 | **0.54** |
| Oslo | **0.46** | **0.49** | **0.67** | 0.13 | **0.56** |
| Copenhagen | **0.46** | 0.23 | **0.61** | **0.63** | **0.68** |
| Rotterdam | **0.70** | **0.85** | **0.79** | **0.63** | **0.77** |
| Leipzig | **0.78** | **0.63** | **0.65** | **0.73** | *N/A* |
| Brussels | **0.77** | **0.64** | **0.66** | **0.80** | **0.80** |
| Lille | **0.58** | 0.38 | **0.75** | **0.74** | **0.80** |
| Prague | **0.54** | **0.48** | **0.61** | **0.65** | **0.64** |
| Paris | **0.72** | **0.76** | **0.75** | **0.73** | *N/A* |
| Bern | **0.64** | **0.57** | **0.71** | **0.59** | **0.54** |
| Milan | **0.73** | **0.82** | **0.82** | **0.71** | *N/A* |
| Barcelona | **0.56** | **0.58** | **0.78** | **0.53** | **0.58** |
| Athens | 0.29 | 0.34 | 0.17 | 0.36 | **0.62** |
| Seville | **0.47** | *N/A* | 0.41 | **0.50** | *N/A* |
| Granada | **0.56** | 0.40 | **0.68** | 0.37 | 0.07 |
| Nicosia | 0.38 | 0.24 | **0.58** | **0.49** | 0.36 |
| | | | | | |
| HYY | **0.81** | 0.35 | 0.43 | 0.37 | **0.50** |
| BIR | 0.11 | *N/A* | **0.56** | **0.61** | **0.74** |
| RIS | **0.60** | 0.27 | 0.42 | **0.60** | **0.67** |
| CBW | **0.83** | **0.77** | **0.81** | **0.63** | **0.71** |
| MEL | **0.81** | **0.69** | **0.65** | **0.59** | **0.65** |
| KOS | **0.57** | 0.45 | **0.47** | **0.70** | **0.68** |
| SIR | **0.75** | **0.66** | **0.63** | **0.77** | **0.76** |
| PAY | **0.72** | **0.56** | **0.64** | **0.61** | *N/A* |
| IPR | **0.66** | **0.57** | **0.75** | **0.63** | *N/A* |
| MSY | **0.47** | 0.13 | 0.43 | 0.33 | 0.29 |
| ARN | **0.61** | *N/A* | **0.77** | 0.00 | *N/A* |
| CYP | 0.20 | 0.06 | 0.44 | **0.66** | 0.41 |

Table S5. Regressions between national monthly road fuel consumption (source: EUROSTAT) and monthly mean driving direction request (source: Apple®) indices for the time period January – May 2020. Fuel consumption and driving direction request data are normalised to January 2020 and 13 January 2020 data, respectively.

| | gasoline | | | diesel | | |
|---|---|---|---|---|---|---|
| | slope | slope relative uncertainty | $R^2$ | slope | slope relative uncertainty | $R^2$ |
| Finland | 0.49 | 41% | 0.66 | -0.36 | 37% | 0.71 |
| Norway | 0.42 | 44% | 0.63 | 0.05 | 280% | 0.04 |
| Denmark | 0.53 | 67% | 0.43 | -0.41 | 59% | 0.49 |
| Netherlands | 0.70 | 19% | 0.90 | -0.67 | 56% | 0.51 |
| Germany | 0.48 | 33% | 0.76 | -0.19 | 105% | 0.23 |
| Belgium | 0.88 | 23% | 0.86 | -0.03 | 936% | 0.00 |
| France | 0.80 | 23% | 0.86 | 0.39 | 33% | 0.76 |
| Czech Republic | 0.38 | 50% | 0.57 | 0.17 | 100% | 0.25 |
| Switzerland(1) | 0.59 | 25% | 0.84 | 0.18 | 95% | 0.27 |
| Italy | 0.52 | 18% | 0.91 | 0.44 | 13% | 0.95 |
| Spain | 0.71 | 13% | 0.95 | 0.37 | 24% | 0.85 |
| Greece | 0.59 | 20% | 0.89 | -0.07 | 240% | 0.05 |

(1) Source for fuel consumption: www.avenergy.ch

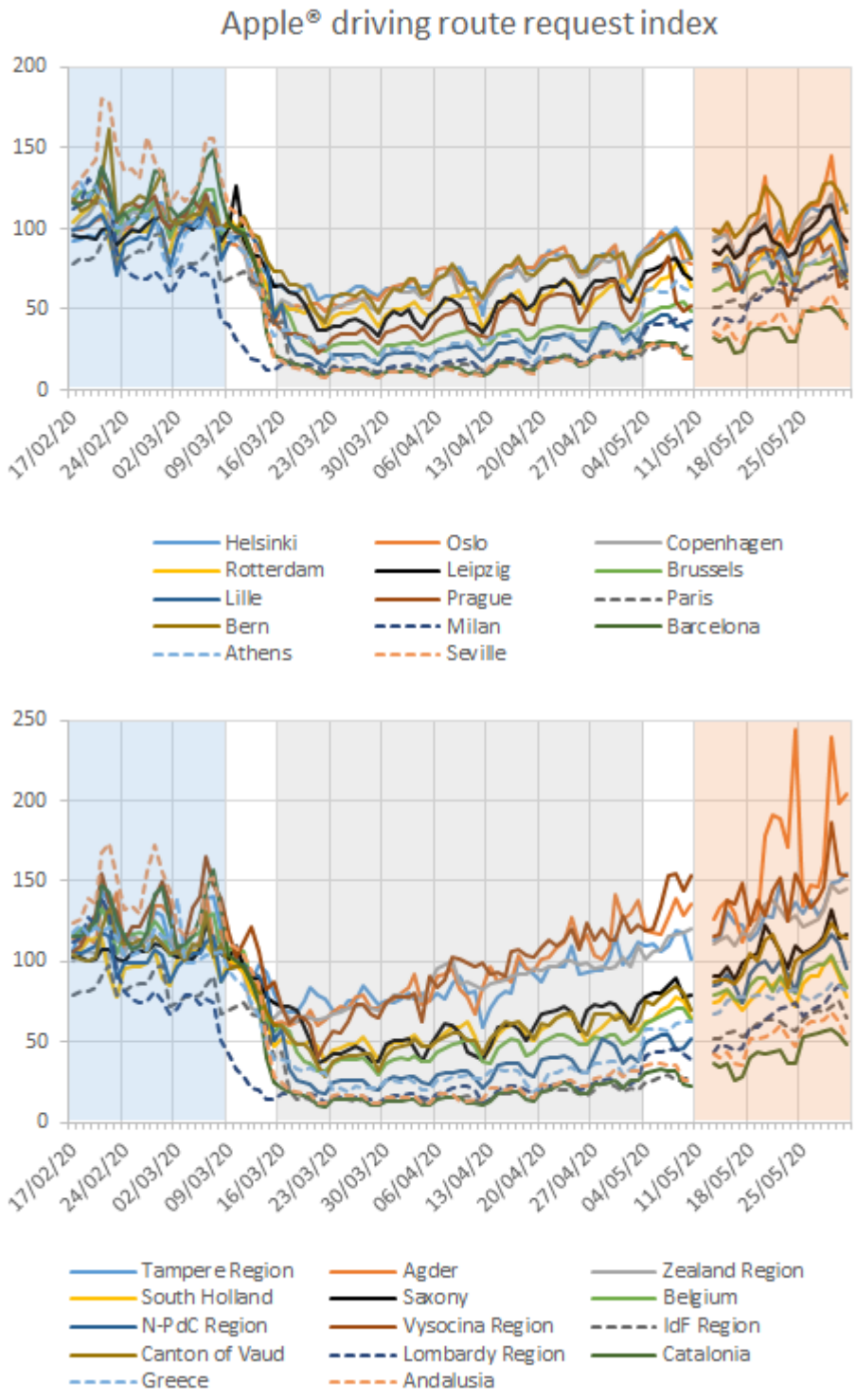


Figure S1: driving route request index from Apple® in cities and regions of the study. The 3 periods A (before), D (during) and P (after lockdown) are highlighted by the light blue, grey, and orange backgrounds, respectively.

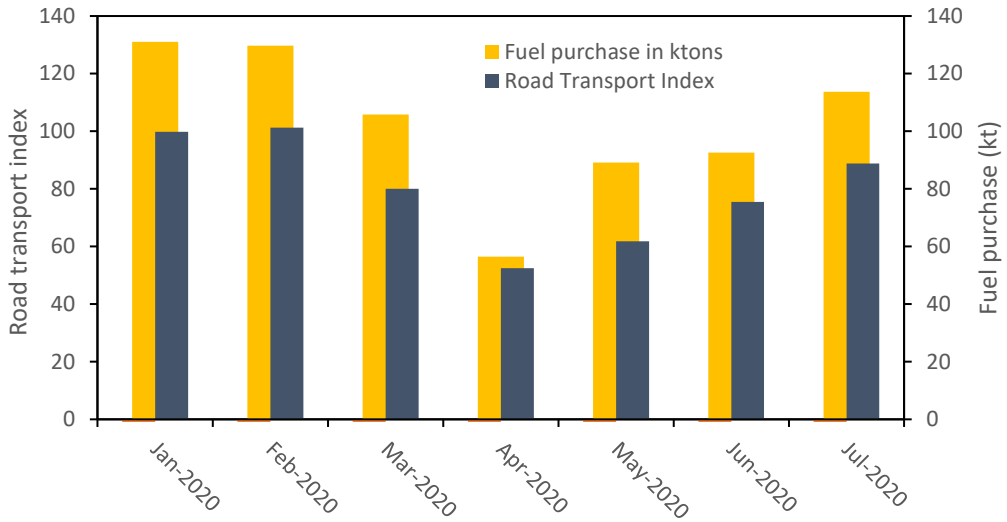


Figure S2. 2020 mobility and fuel purchase data from Cyprus (source: //library.cystat.gov.cy/NEW/MONTH-ECON_IND-TABLE1A1B-JANDEC21-EL-140222.xls). Road transport index 2015 = 100. Fuel purchase is that of oil companies.

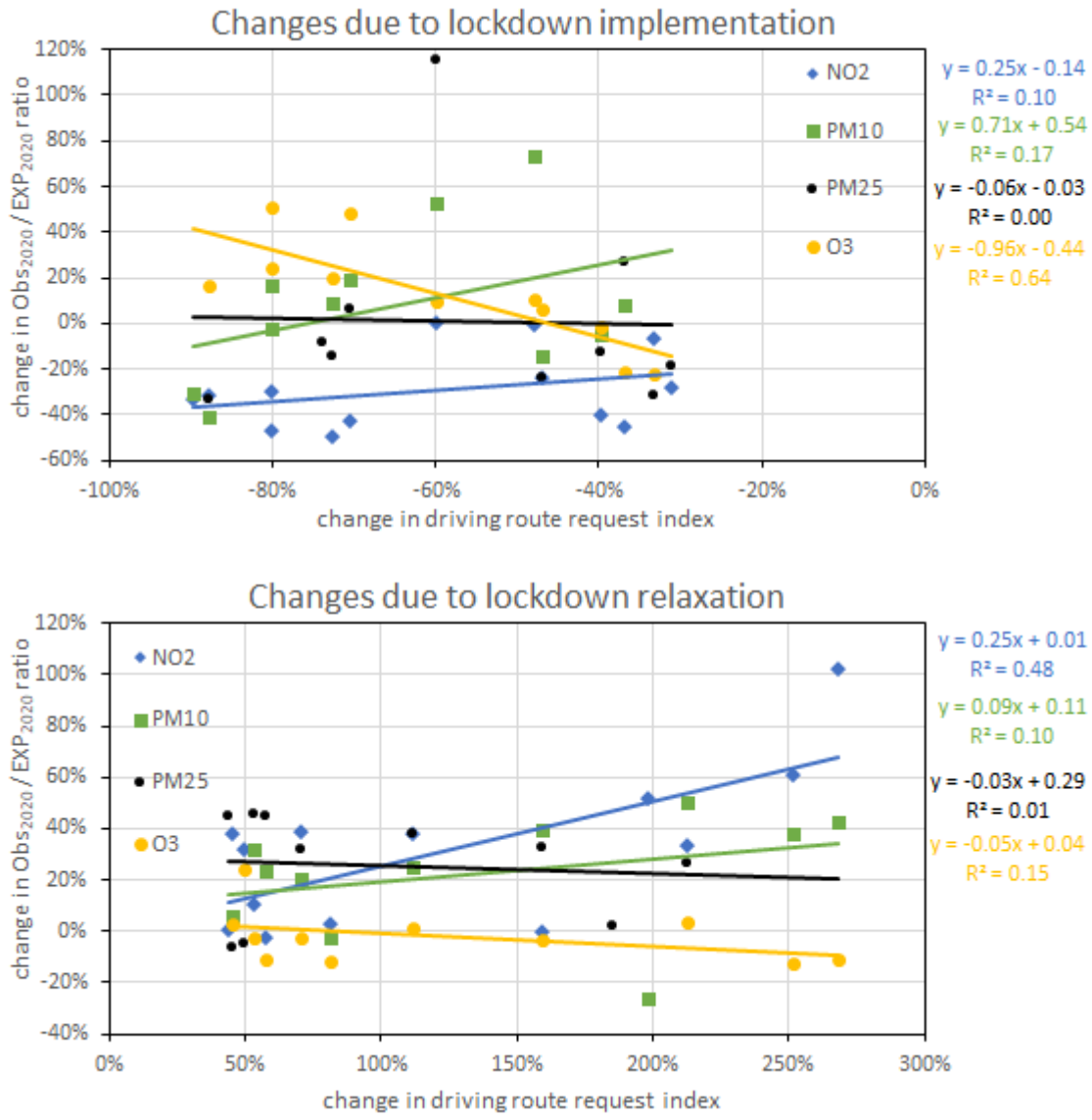


Figure S3. Regressions between changes in observed / expected concentration ratios and driving route request index at urban sites between A and D (top) and between D and P (bottom).

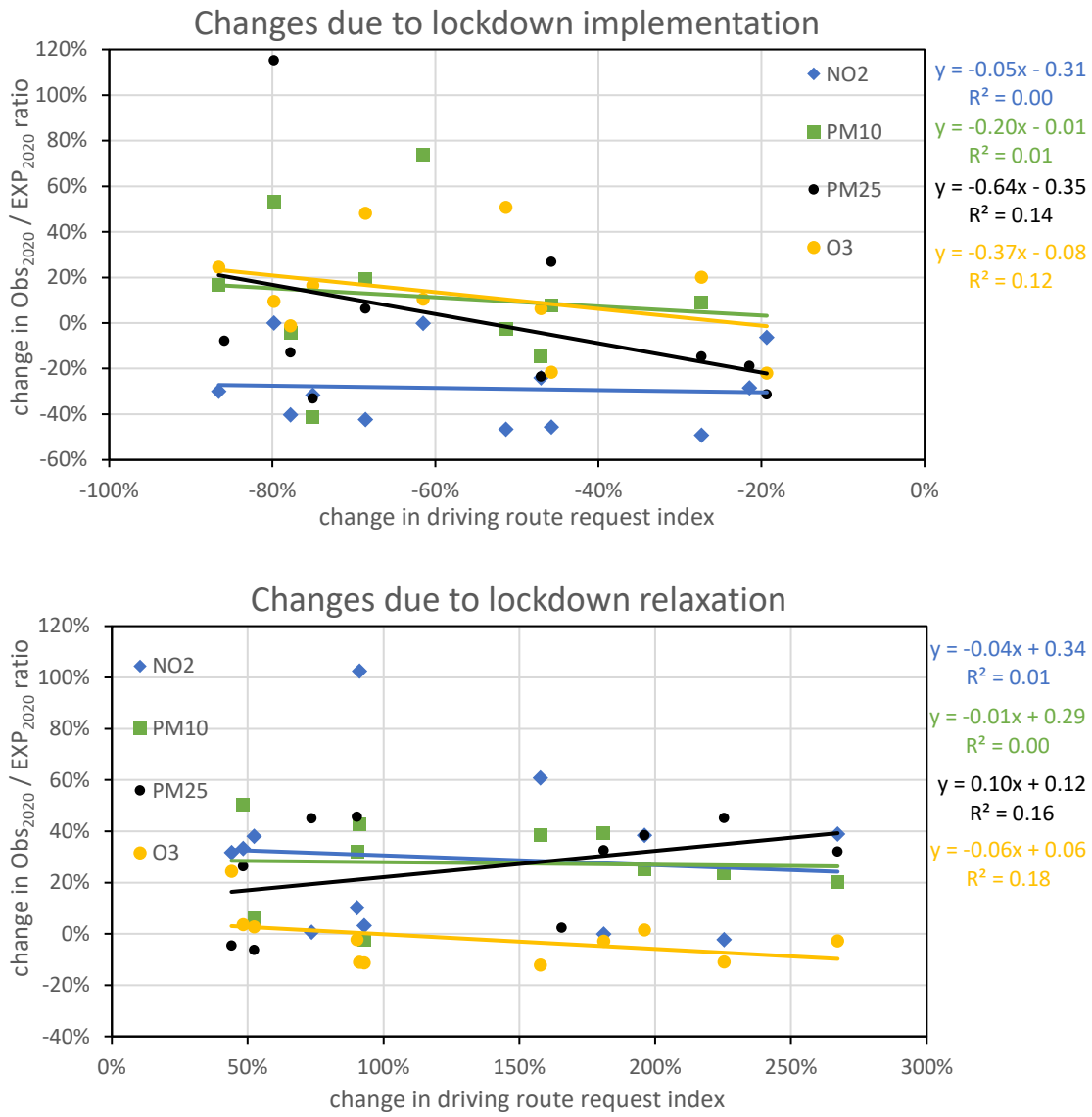


Figure S4. Regressions between changes in observed / expected concentration ratios and driving route request index at regional background sites between A and D (top) and between D and P (bottom).

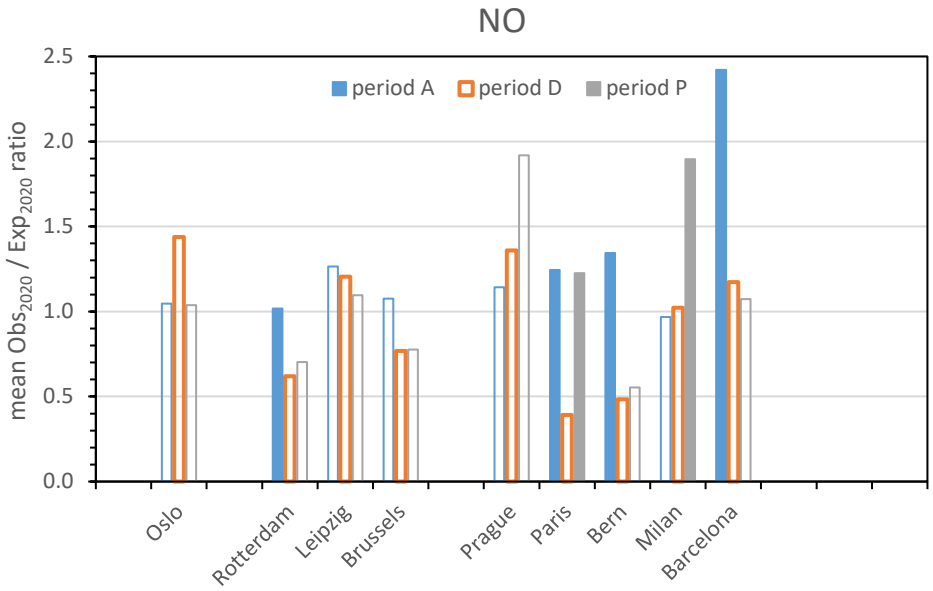


Figure S5. Mean observed / expected NO concentration ratios at urban sites before (A), during (D) and after (P) the lockdown period. Filled bars indicate means which are statistically different from the mean during lockdown period (D) at the 95% confidence level.

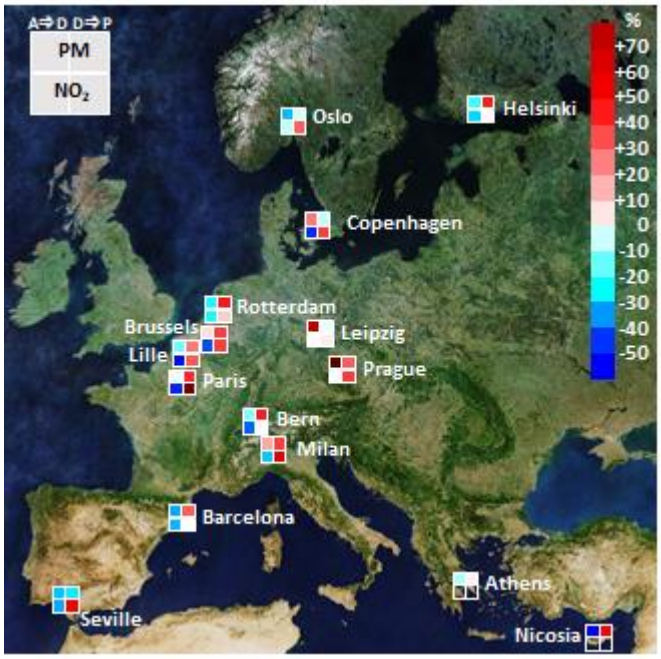


Figure S6: Impacts of lockdown implementations (A⇨D) and relaxations (D⇨P) on PM and $NO_2$ concentrations at 15 urban sites considered in our study. When available (see Table S1), $PM_{2.5}$ data are shown. Map background from ESA.