Quantification of the Emission Changes in Europe During 2020 Due to the COVID-19 Mobility Restrictions

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FAIRMODE technical meeting (on-line)

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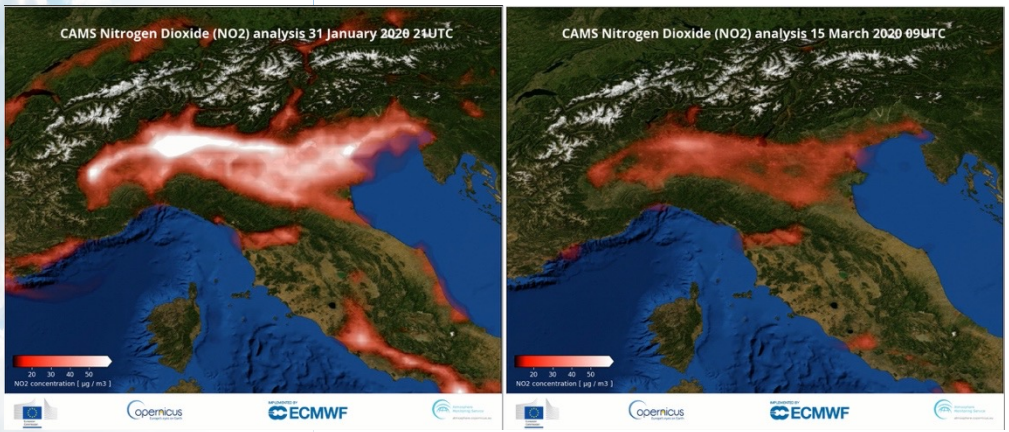
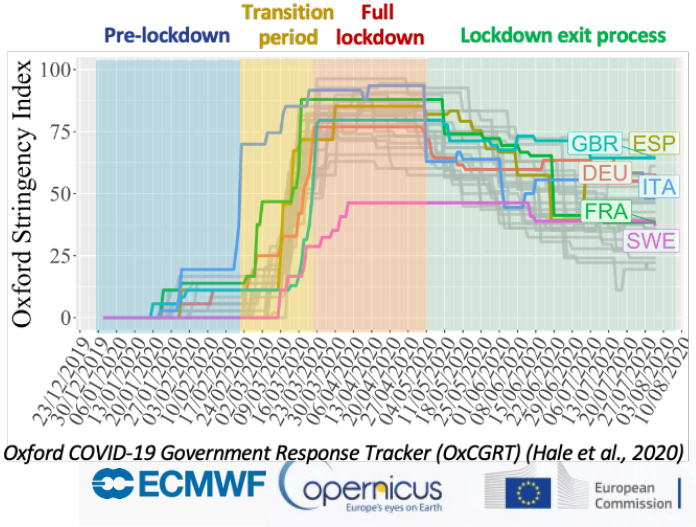
Motivation and objective

- Several studies have assessed the impact of COVID-19 on air pollution through the use of observations. A complete understanding requires also quantifying the reduction of primary emissions.
- **Objective:** To develop emission adjustment factors attributable to the COVID-19 measures, which can be combined with the Copernicus CAMS European emission inventory for air quality modelling
- **Requirements:** To capture heterogeneity of restrictions across countries, changes in time of the restriction levels and diversity in the levels and types of restrictions.





Oxford COVID-19 Government Response Tracker (OxCGRT) (Hale et al., 2020)

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Methodology: Overview

- **Temporal resolution - coverage:** Daily - January to December 2020
- **Spatial resolution – coverage:** Country level – EU27 + UK + Norway + Switzerland
- **Data-driven approach**: Changes in emissions assumed to follow changes observed in national measured time-series representing the main activities of each sector
- **Construction of COVID-19 adjustment factors:** Ratio between the measured activity data for a given day and the value of this activity without the COVID-19 influence (baseline)

Sector	Sources of information
Energy industry	• Electricity demand data: ENTSO-E (2021) • Outdoor temperature: C3S (2017)
Manufacturing industry	• Industrial Production Index: Eurostat (2021)
Residential/Commercial combustion	• Mobility data: Google (2021) – Groceries, residences, workplaces
Solvents (industrial use)	• Industrial Production Index: Eurostat (2021)
Fugitive emissions from fossil fuels	• Industrial Production Index: Eurostat (2021)
Road Transport	• Mobility data: Google (2021) – Transit stations • National measured traffic counts
Shipping	• Port call trends: EMSA (2021)
Aviation	• Airport movement statistics: EUROCONTROL (2021)
Off-road transport	• Industrial Production Index: Eurostat (2021)

Methodology: Road transport

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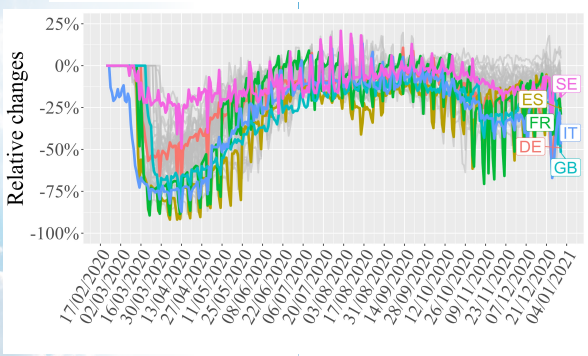
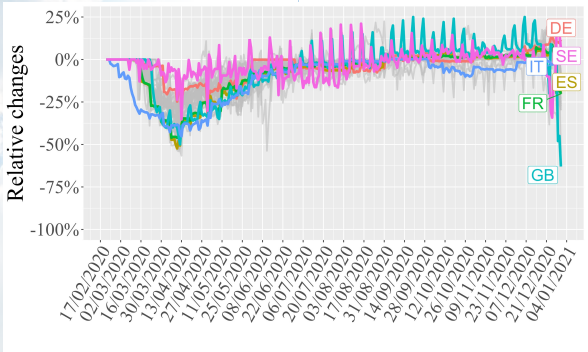
Google COVID-19 Mobility Reports (Google LLC, 2021) **calibrated with trends computed using measured traffic counts**:

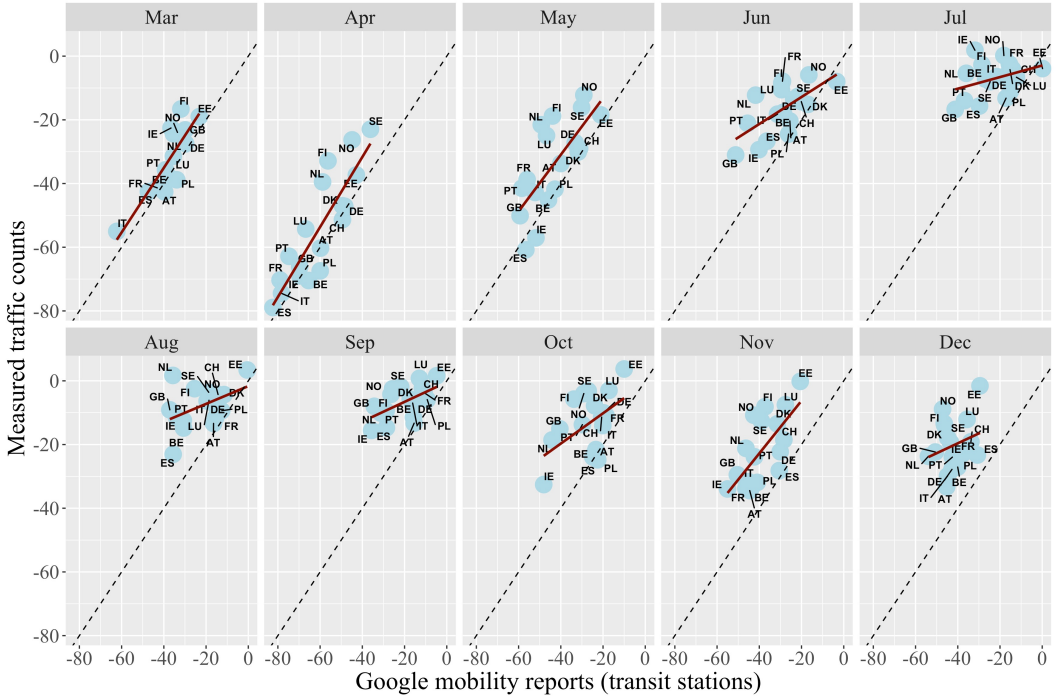
- Google tends to underestimate the recovery of light duty vehicles (LDV) activity during lockdown exit process
- Heavy-duty vehicles (HDV) – considered essential during lockdowns

Road Transport – Light duty vehicles



Road Transport – Heavy duty vehicles





Methodology: Energy industry

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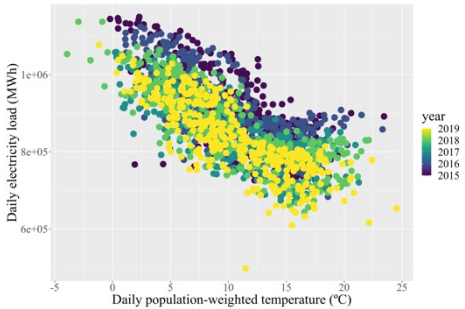
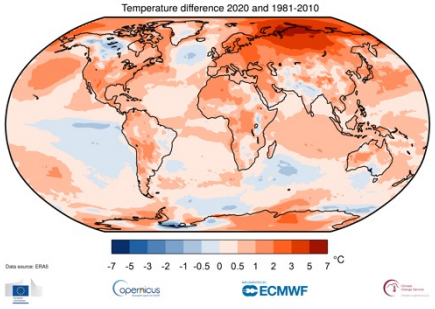
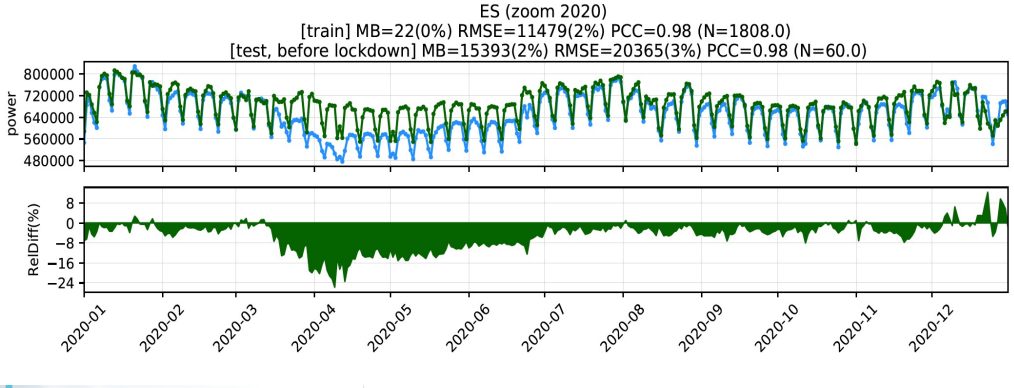
A direct comparison between 2020 and pre-lockdown (2019) electricity demand levels would be influenced by the confounding effect of meteorological variability :

- Changes in electricity consumption are linked to temperature fluctuation
- 2020 was the warmest year on record in Europe (C3S)







Use of Artificial Intelligence to estimate 2020 business-as-usual electricity demand:

- Gradient boosting machine model trained and tuned independently for each country
- Features: ENTSO-E electricity demand & population-weighted ERA5 temperature, Julian date, country-specific national holidays
- Training period: Jan-Jul 2015-2019
- Test period: Jan-Feb 2020

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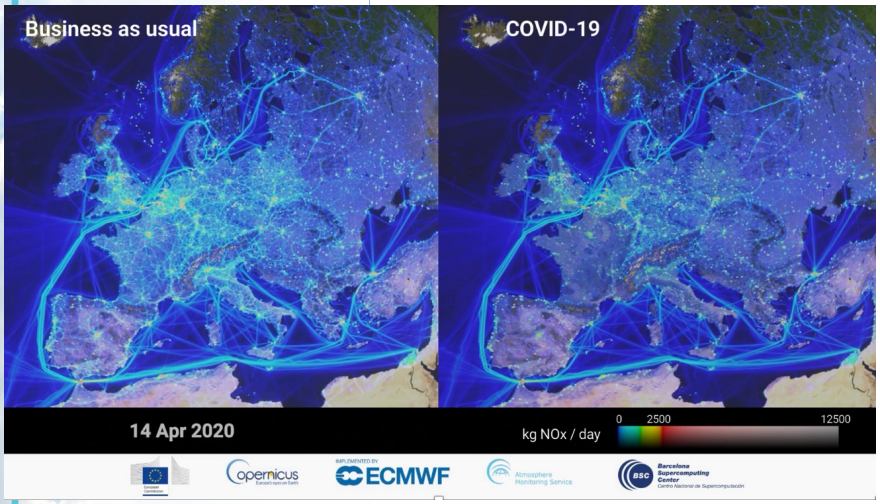
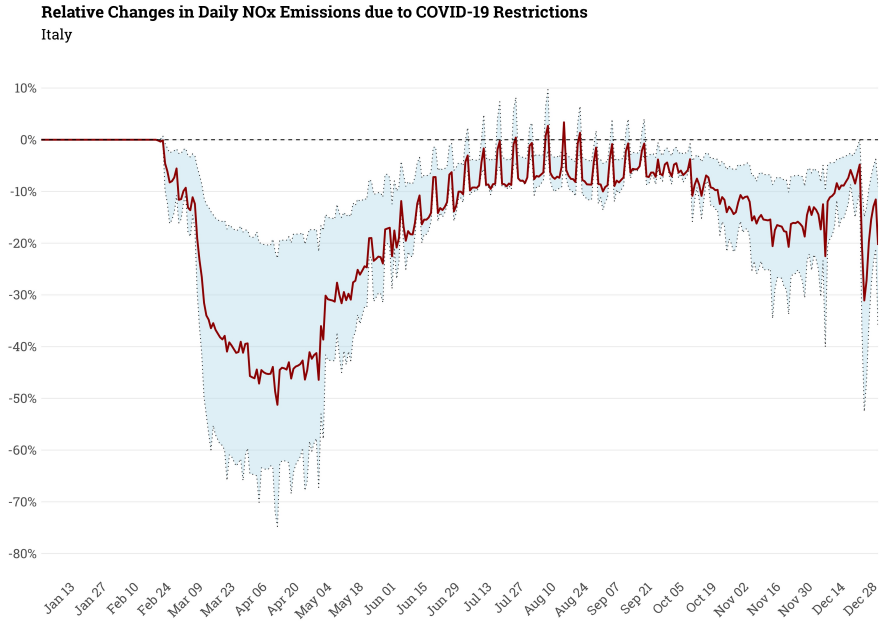
Results: Impact of COVID-19 on emissions

Combination of the adjustment factors with the CAMS-REG 2020 Business-as-Usual (BAU) European gridded emissions, developed by TNO in CAMS_81

- Resulting spatial and temporal disaggregated emissions to be used as input for air quality modelling (CAMS_71; EEA 2020)
- Largest emission reductions found in urban areas and main interurban corridors





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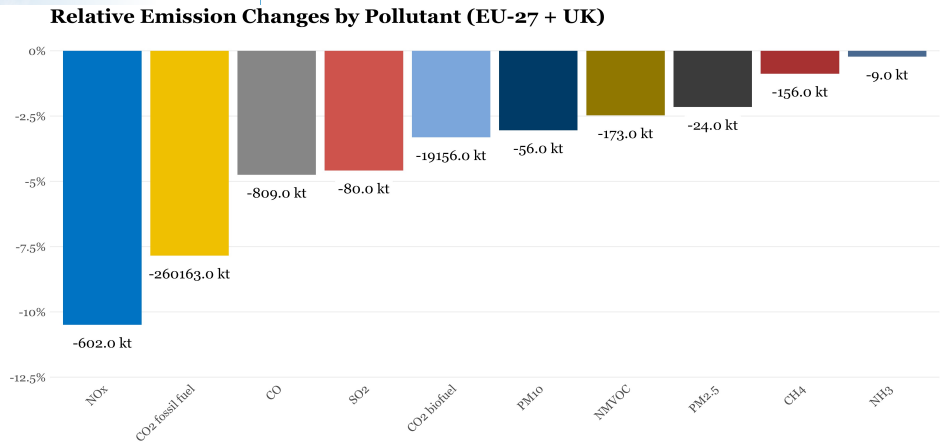
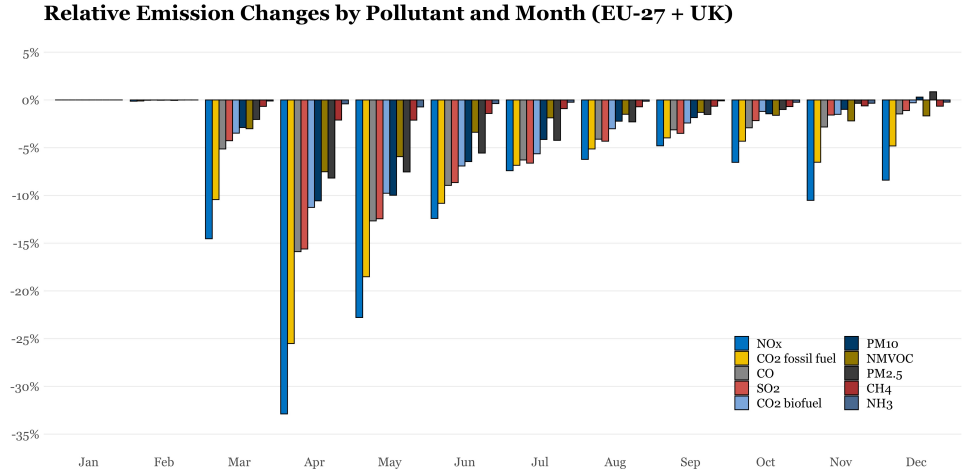
Results: Impact of COVID-19 on emissions





Pollutant breakdown:

- Large contrast between decrease found in NO_x (-10.5%) and PM10 (-3.0%) and PM2.5 (-2.1%) emissions.
- NH_3 and CH_4 practically unaffected as they are linked to agricultural activities and waste management

Temporal analysis:

- Largest decline in European emissions observed during April (up to -32.8% for NO_x)
- Emission levels in September close to pre-lockdown levels (-4.8% for NO_x)
- Emission reductions during the second wave much lower than those occurred during the Spring lockdowns (e.g., -10.5% for NOx and +1.1% for PM2.5)

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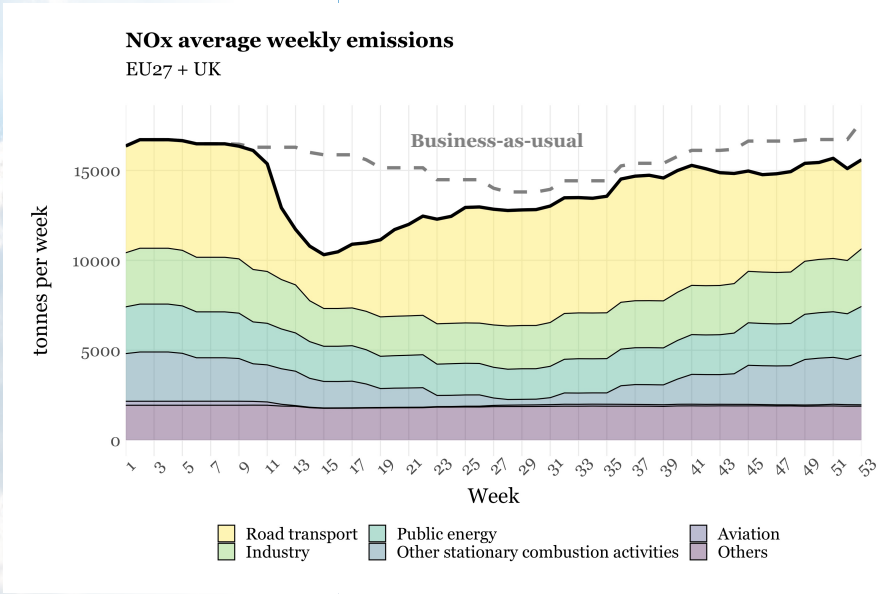
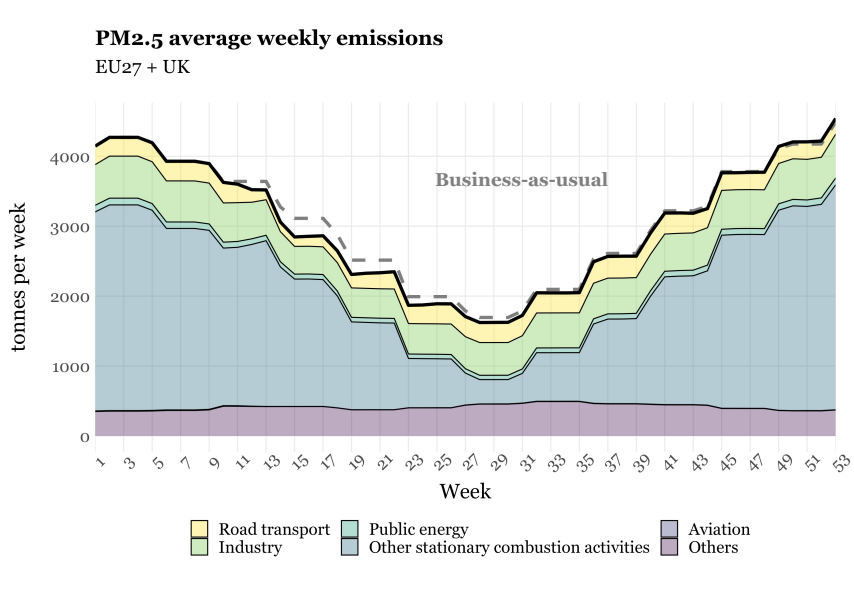
Results: Impact of COVID-19 on emissions

- NO_x and PM2.5 emission changes mainly driven by changes in road transport and residential wood combustion activities, respectively
- Largest emission declines found in aviation (-51% / -56%) and road transport (-15.5% / -18.8%) - but different recovery rates





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Comparisons with other emission results

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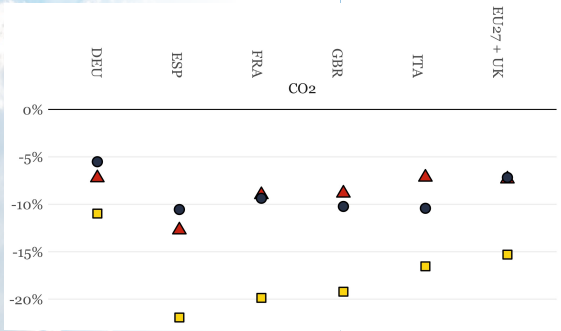
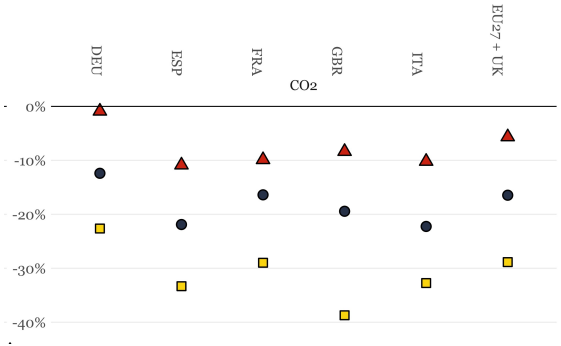
- Forster et al. (2020): systematically presents relative reductions between two and three times as large as the ones computed in the present work.
- Liu et al. (2020): total CO_2 emission declines are practically equal. However, large discrepancies appear when comparing the results for individual sectors (e.g., road transport reductions three times lower)

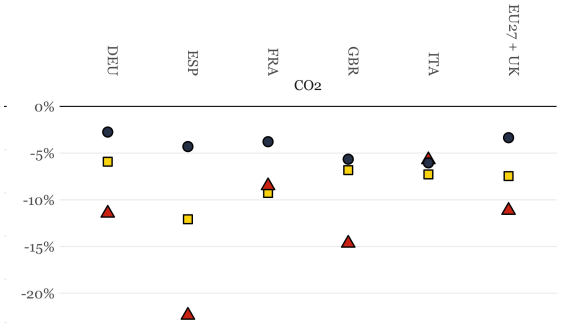
All sectors



Road transport



Power industry



Forsteretal2020 Liuetal2020 This work

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Take home messages

- New CAMS emission product developed to help quantifying the impact of lockdown policies during the COVID-19 pandemic:
  - Adjustment factors per country, pollutant, sector and day to reflect the heterogeneous impact of restrictions
  - Use of a data-driven approach, combining traditional proxies with new mobility datasets and AI techniques
  - Resulting dataset can be combined with the CAMS European emissions for air quality modelling
- Key findings of the comparison between business-as-usual and COVID-19 emission scenarios:
  - **Pollutant breakdown**: Largest contrast between decrease found in NO_x (-10.5%) and PM2.5 (-2.1%) emissions
  - **Sectoral level**: Largest emission declines found in aviation and road transport (but different recovery rates)
  - **Comparisons:** Significant discrepancies with emission results reported by literature – need more investigation
- More information on the methods and project results can be found at:
  - Guevara et al. (2021, ACP)
  - Access and use most recent dataset: marc.guevara@bsc.es (soon to be published through CAMS)

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