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Time-resolved emission reductions for atmospheric chemistry modelling in Europe during the COVID-19 lockdowns

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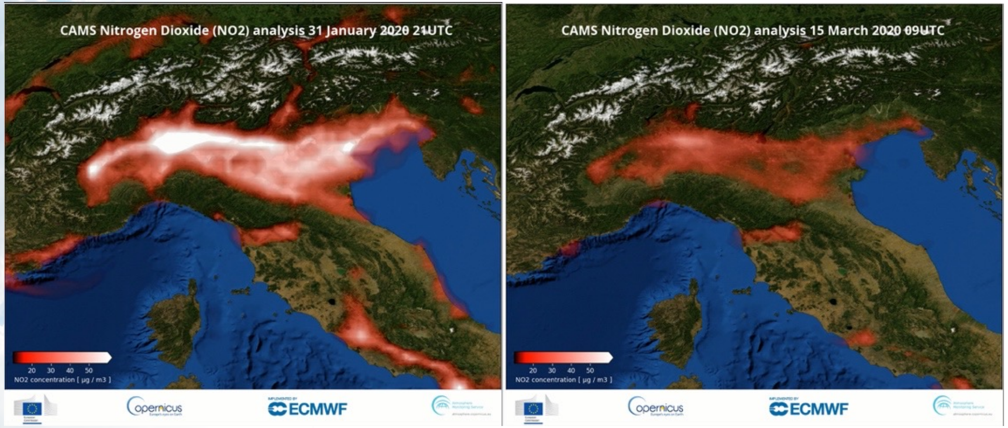
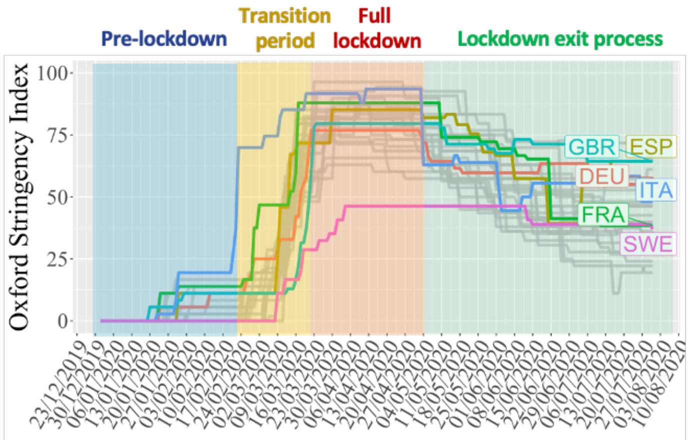
Motivation and objective

- Several studies have assessed the impact of COVID-19 on air pollution through the use of satellite 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)

Methodology: General approach

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- **Sectors considered:** road transport, aviation, shipping, residential/commercial combustion, energy and manufacturing industry.
- **Temporal coverage:** February to July 2020 (currently working on the extension up to December 2020)
- **Data-driven approach**: Changes in emissions assumed to follow changes observed in national measured time-series representing the main activities of each sector (e.g., number of flights, road traffic counts, energy consumption statistics)
- **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)
- **Selection of a baseline:**
  1. **Pre-lockdown period**: e.g. Jan-Feb 2020, before lockdowns started, or the closest date from 2019
  2. **2020 Business-as-usual scenario** (as if COVID-19 did not exist)

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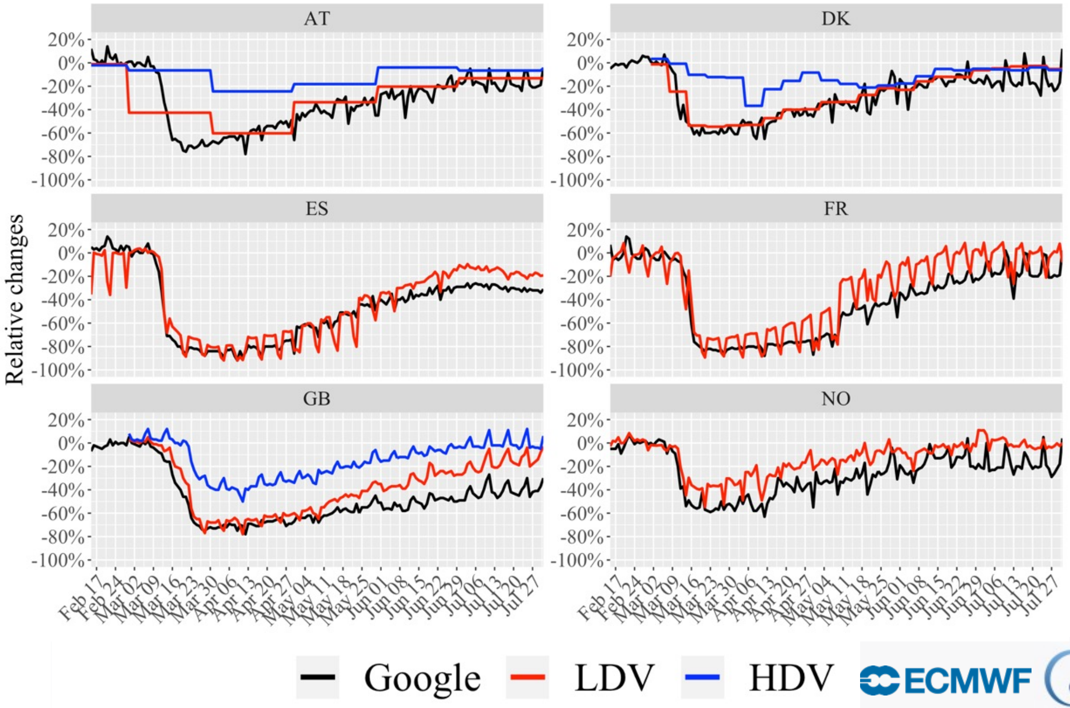
Methodology: Road transport

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
- Google is not representative of changes observed in heavy-duty vehicles (HDV) – considered essential



Methodology: Energy industry

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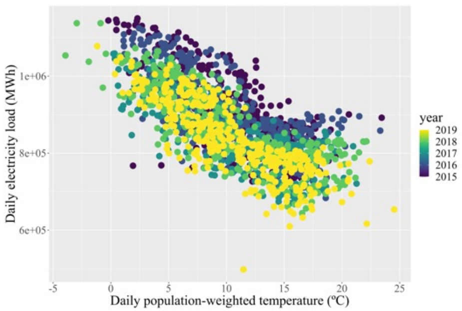
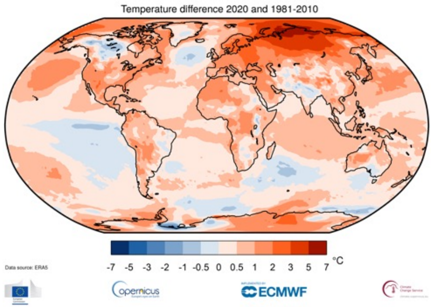
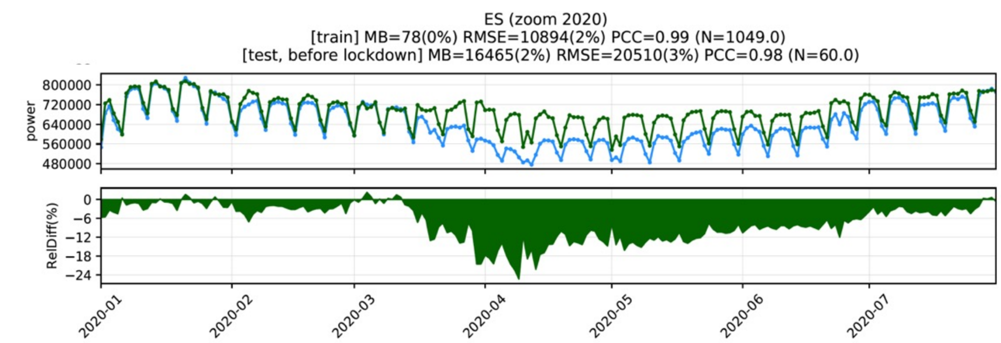
A direct comparison between 2020 and pre-lockdown (2019) electricity demand levels would be influenced by the confounding effect of meteorological variability :

- 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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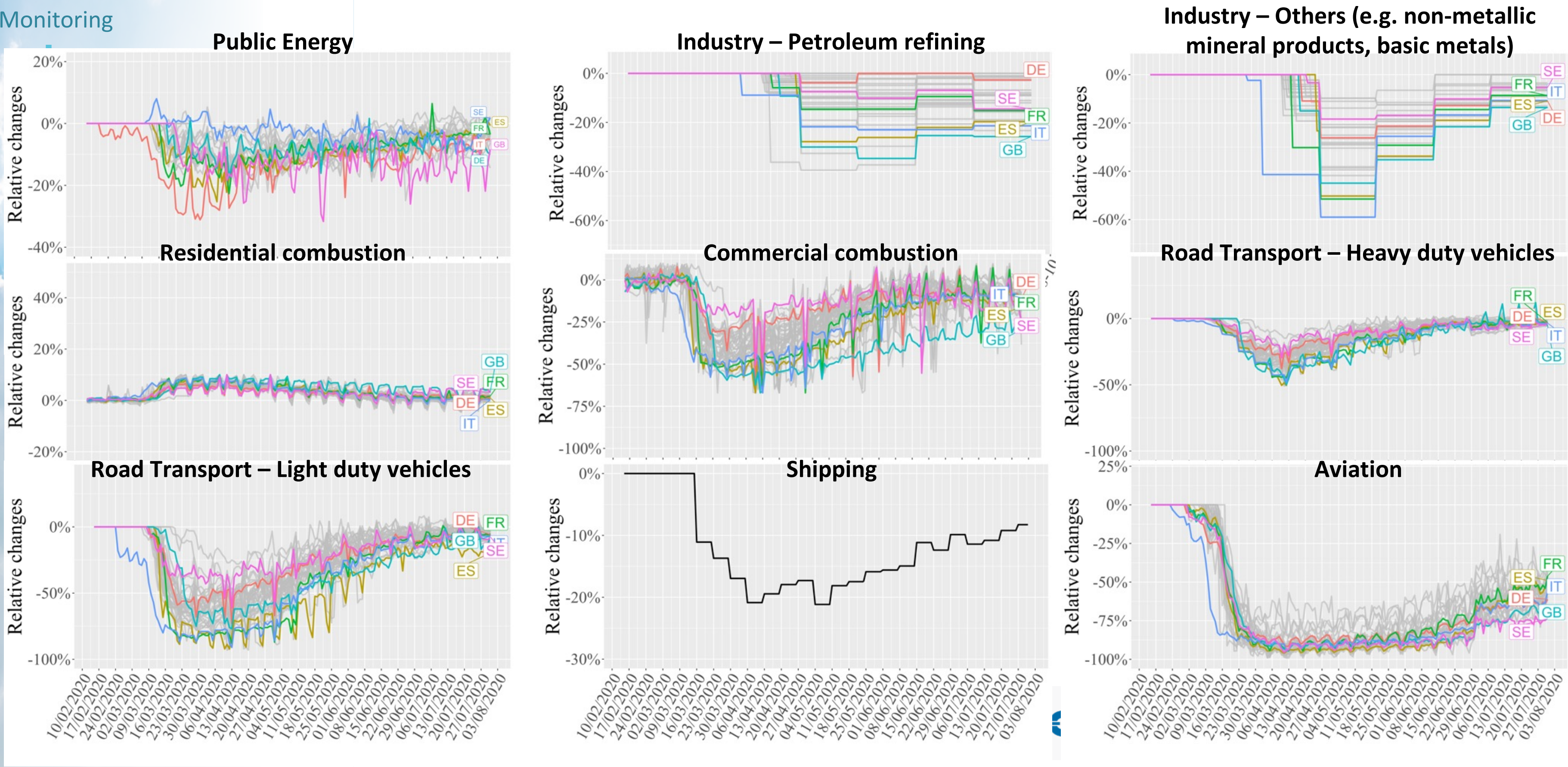
Results: Emission adjustment factors



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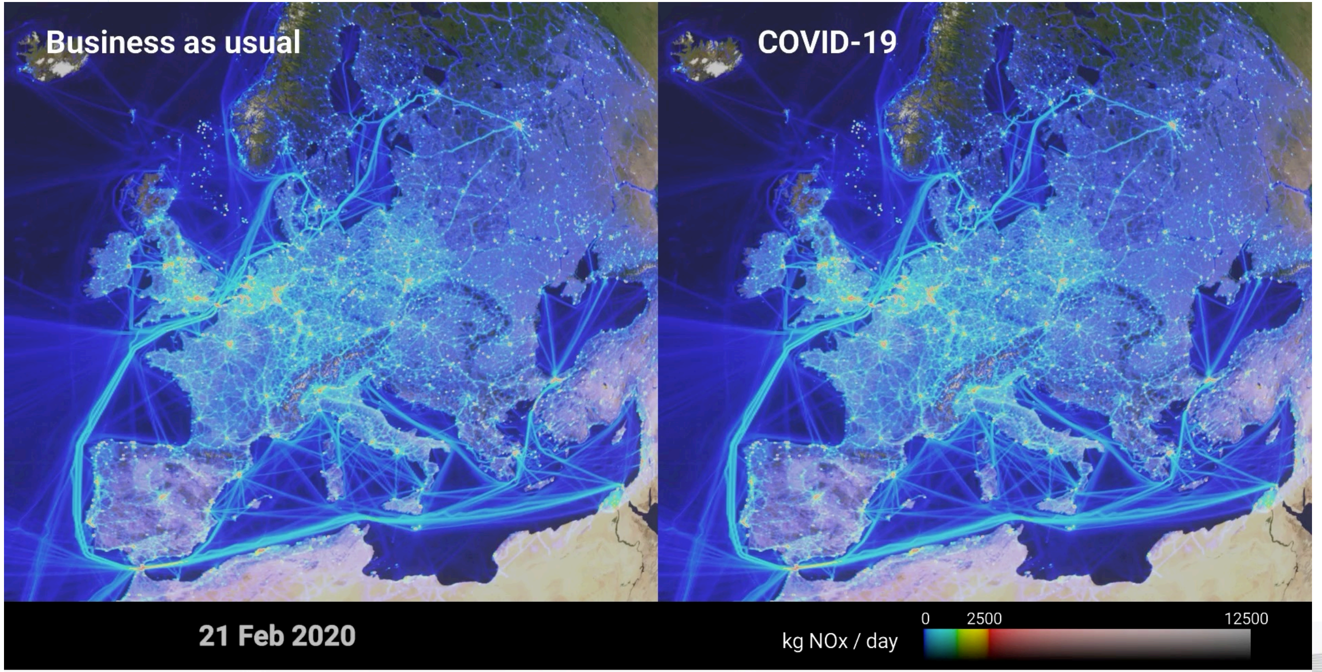
Results: COVID-19 effect on Emissions

Input for air modellers: Combination of the adjustment factors with the CAMS-REG 2020 BAU European gridded emissions

- High resolution and time-resolved emissions for air quality modelling (multi-model run performed in CAMS_71)
- Heterogeneous impact on total emission changes across countries (up to -50% in Italy, France and Spain)
- Largest emission reductions found in urban areas and main interurban corridors



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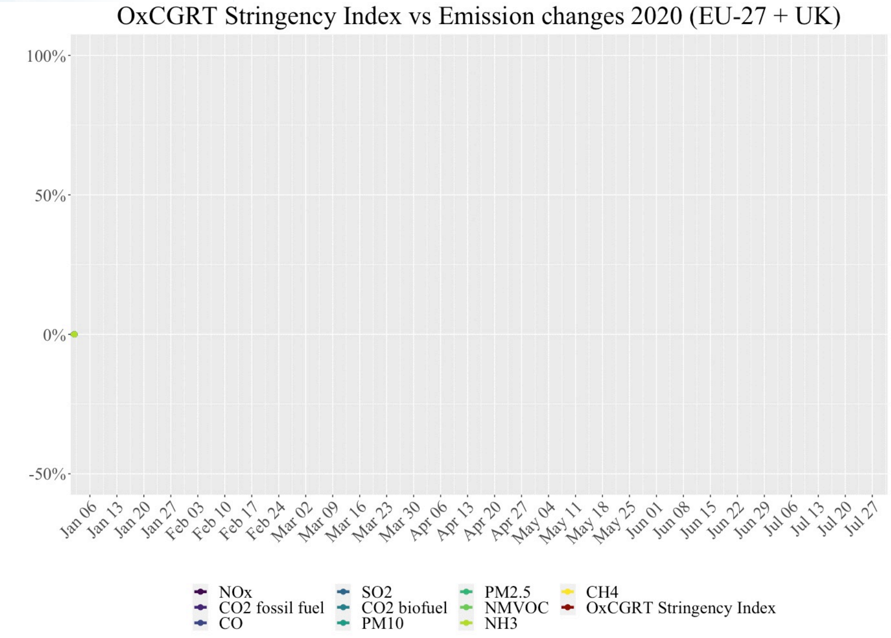
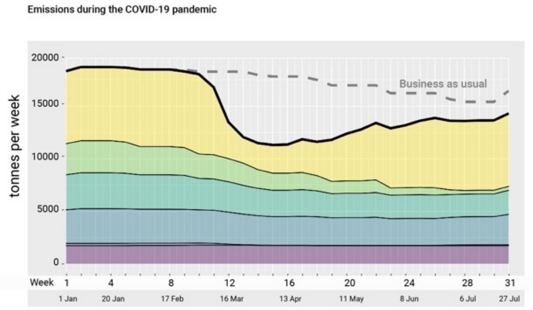
Results: COVID-19 effect on Emissions

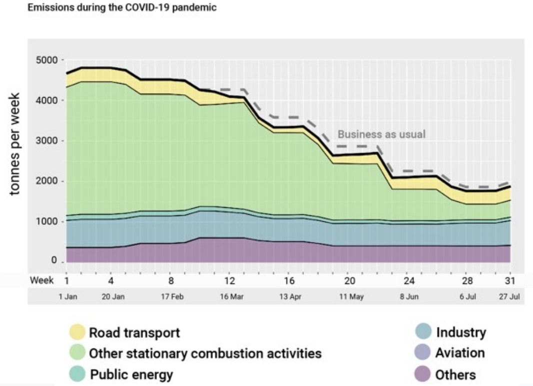
- Input for policy makers: Links between changes in emissions and stringency of the government measures (Hale et al., 2021)
- Largest decrease found for NO_x (-13.1% between Jan-Jul), which were primarily driven by changes in road transport
- Lower drops found for PM2.5 (-4.1% between Jan-Jul), as emissions are mainly driven by residential combustion activities



NO_x average weekly emissions (EU27+UK)



PM2.5 average weekly emissions (EU27+UK)



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Take home messages

- CAMS emission adjustment factors developed to help quantifying the impact of lockdown policies during the COVID-19 pandemic:
    - Adjustment factors provided by country, pollutant sector and day to reflect the heterogeneous implementation of restrictions and their impacts
    - Use of a data-driven approach, which combines the use of traditional proxies with new mobility datasets and artificial intelligence techniques
    - Resulting dataset to be combined with the CAMS European emissions to help to the scientific community in air quality modelling and policy makers for the design of future plans
- Key findings of the comparison between business-a-usual and COVID-19 emission scenarios:
    - **Sectoral level**: Largest emission declines found in aviation and road transport (but different recovery rates)
    - **Country-level contribution**: Italy, France, Spain, the United Kingdom and Germany are, together, the largest contributors to the total EU-27 + UK emission decreases
    - **Spatial level**: Largest emissions reductions in urban areas and main interurban roads
    - **Pollutant breakdown**: Largest contrast between decrease found in NO_x and PM emissions
- More information on the methods and project results can be found at:
    - Guevara et al. (2021, ACP)
    - CAMS press release

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