Short-term effect of COVID lockdown measures on air quality in Europe

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& contribution from the CAMS regional modelling teams

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Lock-down effect on AQ, Spring 2020

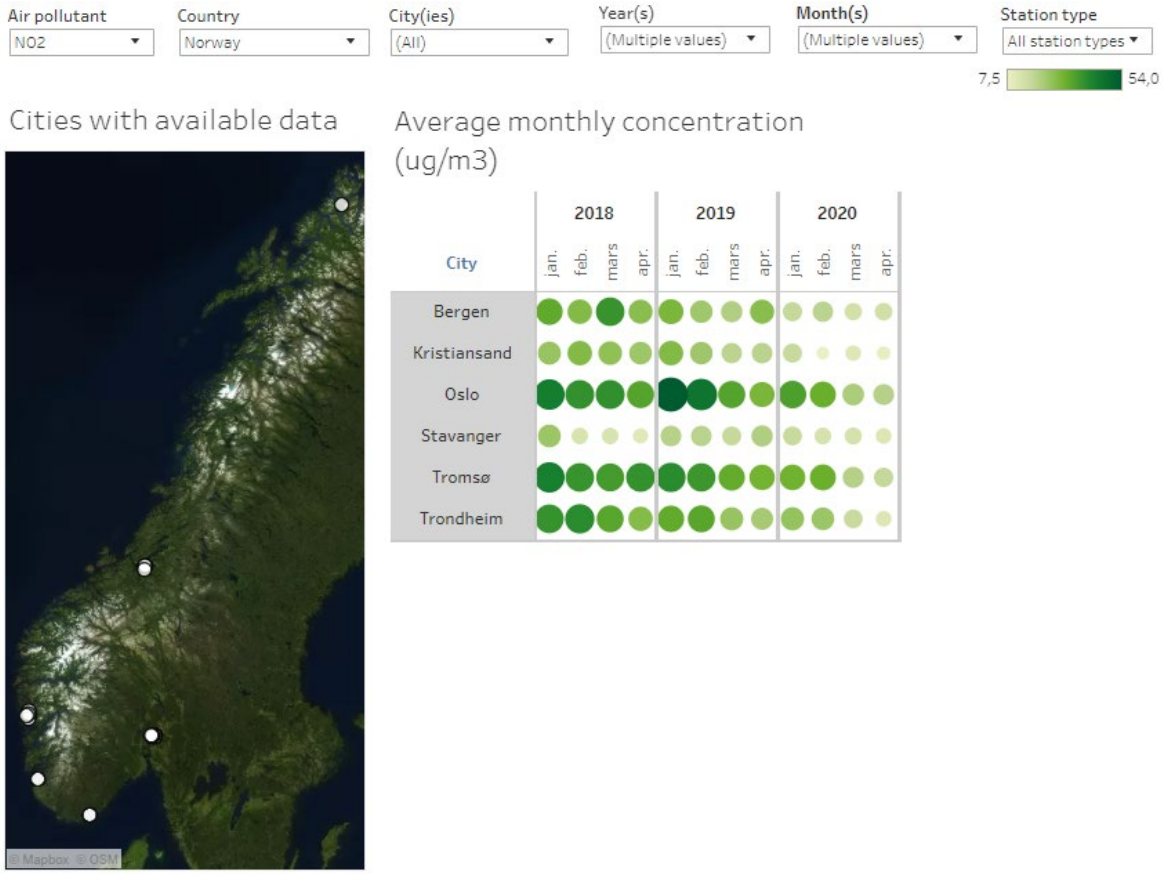
EEA Viewer: AQ & COVID

AQ in Europe report 2020

- Satellite observations (NO_2)
- Lockdown impact on NO_2 and PM_{10} concentrations:
  - ✓ in situ monitoring data
  - ✓ statistical modelling
  - ✓ chemical transport modelling

EEA viewer: Air quality and COVID-19

For NO_2, PM_{10}, $PM_{2.5}$ measured air quality data from 31 countries
week/month average



European Environment Agency

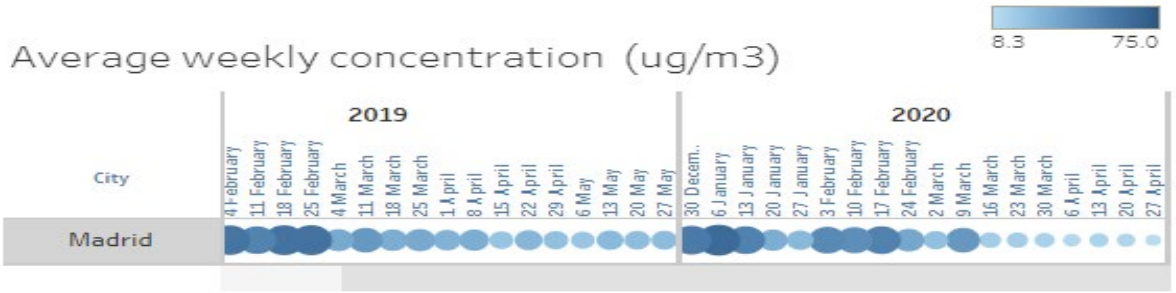
https://www.eea.europa.eu/themes/air/air-quality-and-covid19

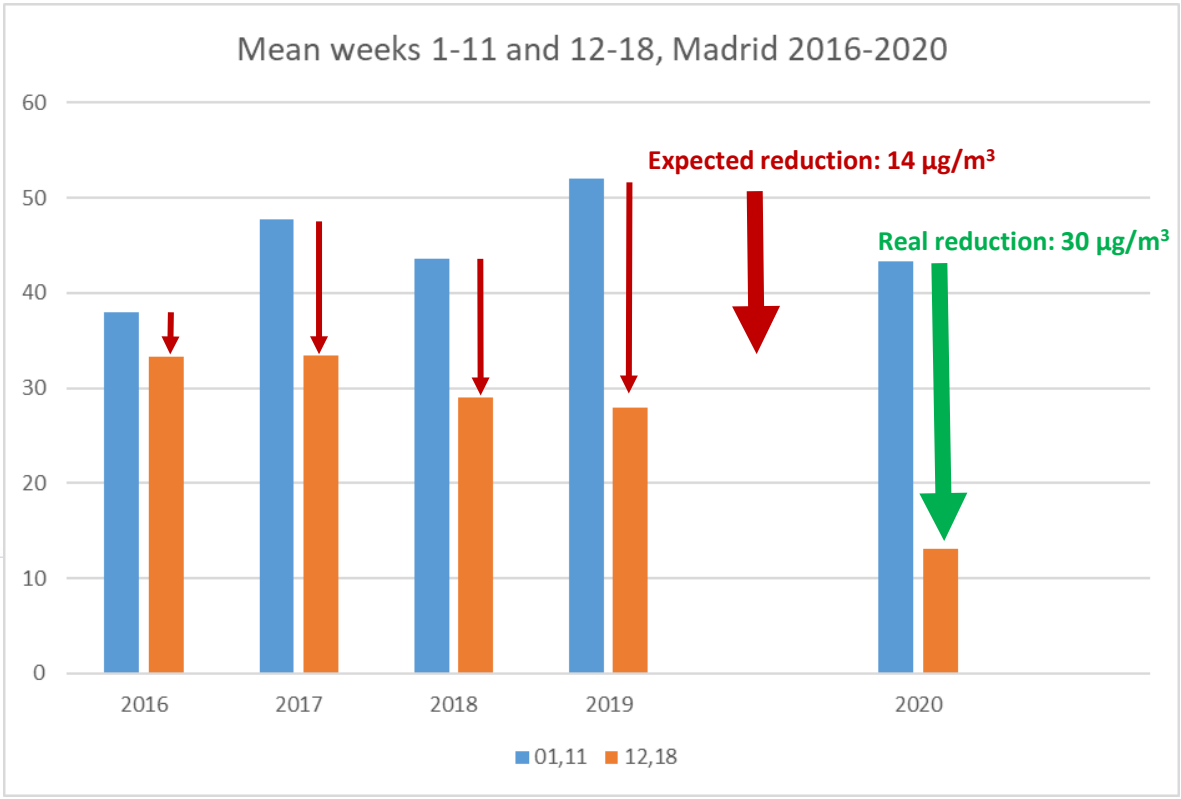
Madrid: NO_2

Air pollutant: NO2 | Country: Spain | City(ies): Madrid | Year(s): (Multiple values) | Month(s): (Multiple values) | Station type: All station types

Cities with available data

Average weekly concentration (ug/m3)





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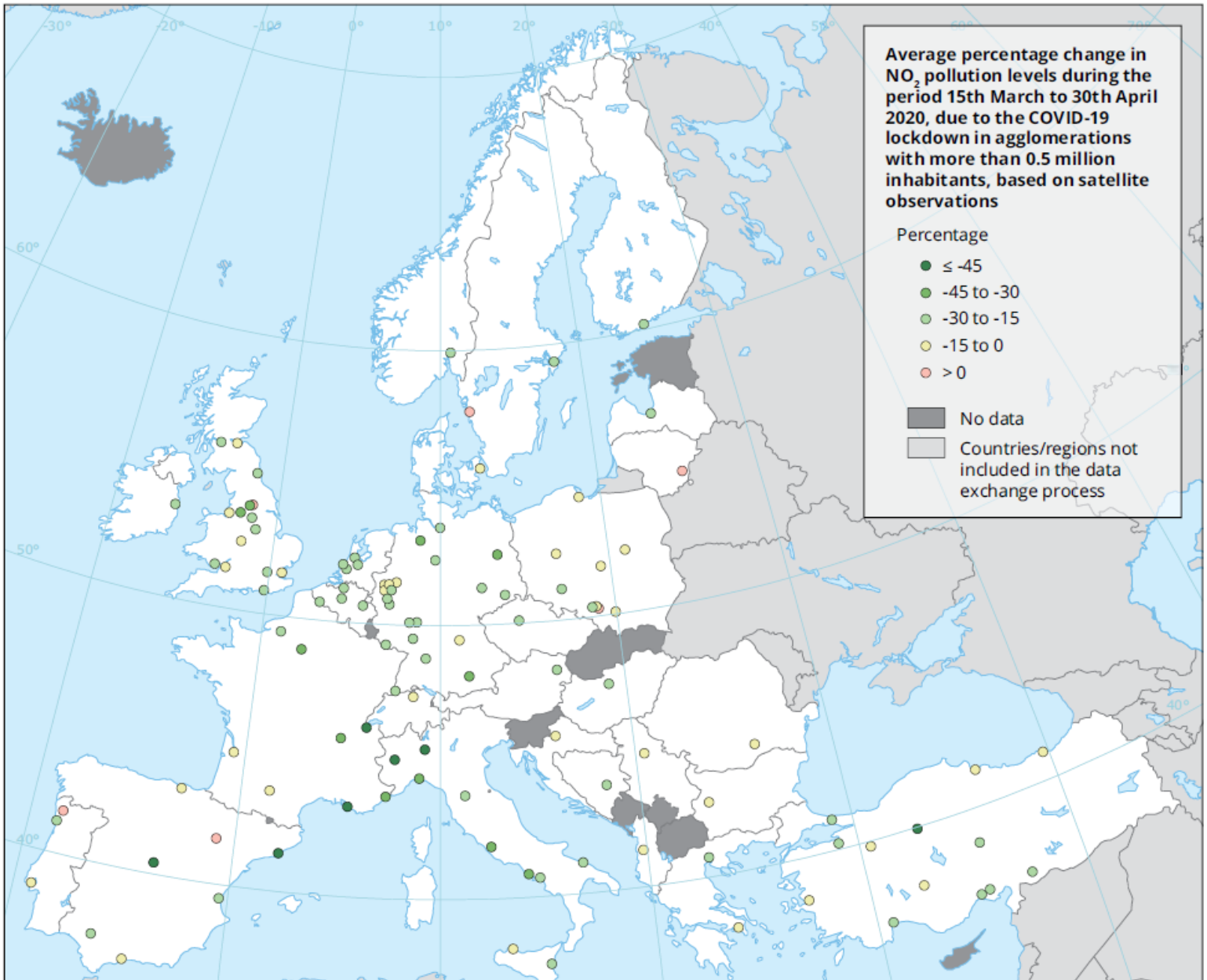
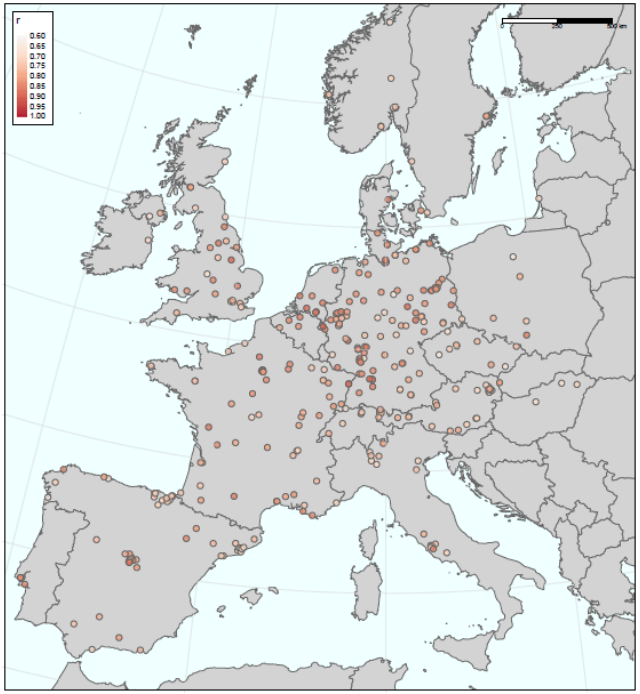
Atmosphere Monitoring

Map 2.2 **Average percentage change in NO_2 pollution levels during the period 15 March to 30 April, due to the COVID-19 lockdown in agglomerations with more than 0.5 million inhabitants, based on satellite observations**



Statistical model (GAM) for prediction of concentrations at measuring stations in Europe considering meteorology

- Nonlinear regression model
- Uses custom smooth functions of a set of meteorological covariates to predict concentrations at the measuring stations
- Uses covariates for the day of the week; day in season and long-term trend
- Meteorological data is based on ECMWF model data
- Training data for Feb-Apr 2015 - 2019 -> predict "business-as-usual" concentrations of **NO_2**, **PM_{10}**, **$PM_{2.5}$**, O_3 in Feb-Apr 2020



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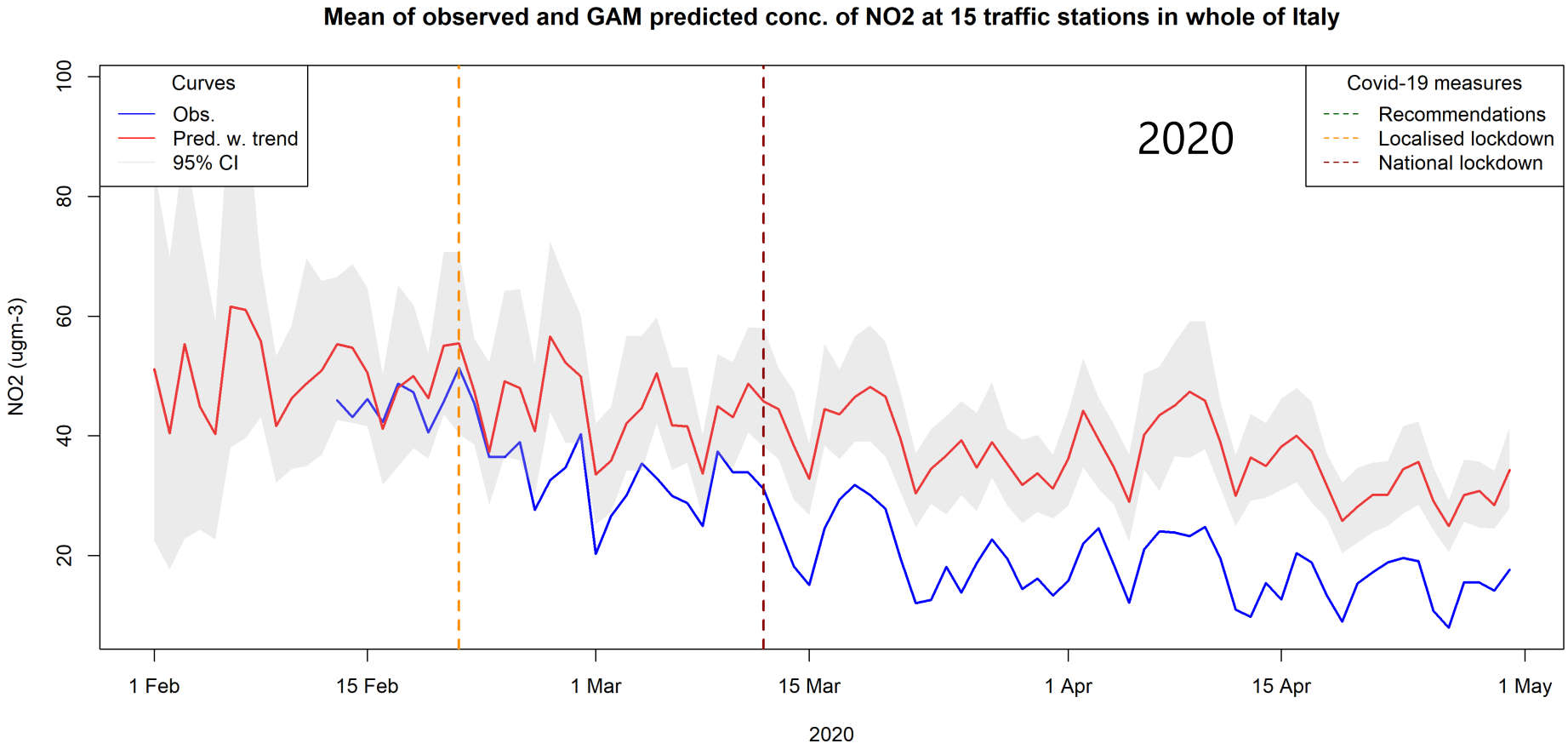
NO_2 at traffic stations in Italy



Training data is used for Feb-Apr 2015-2019

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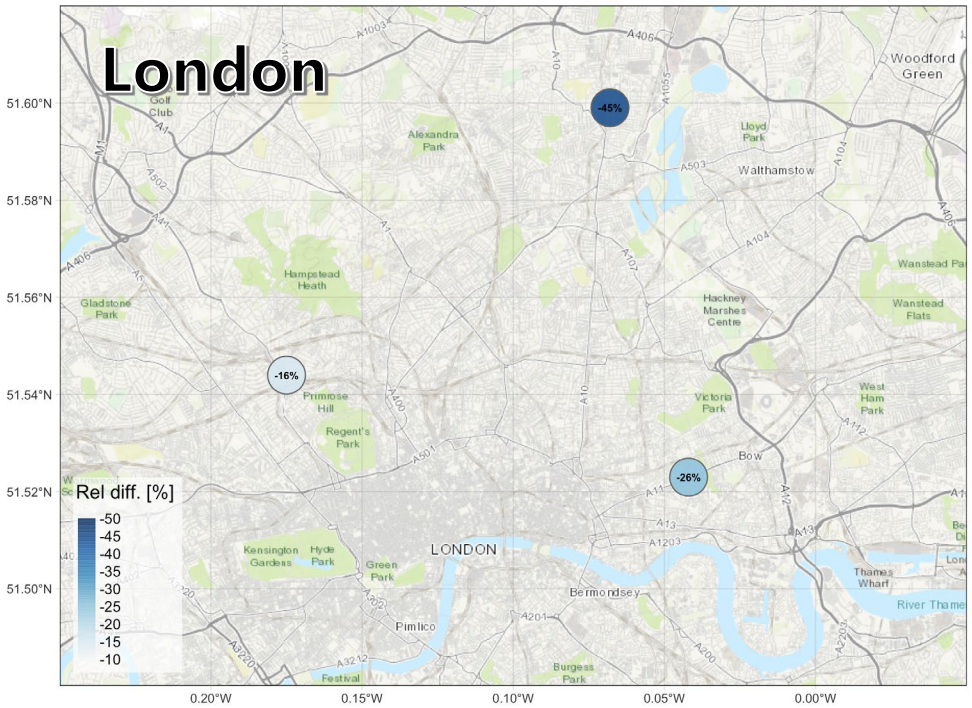
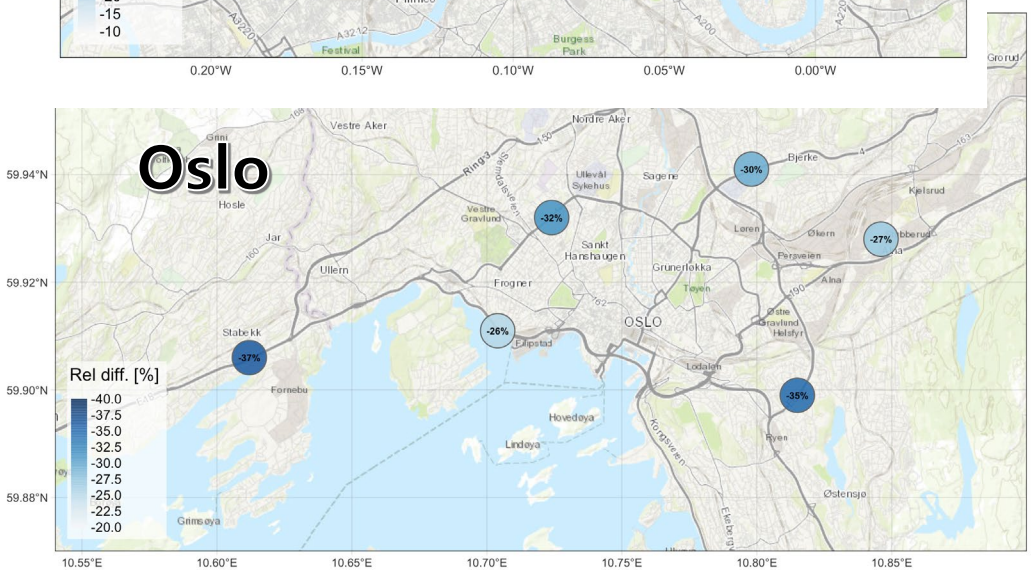
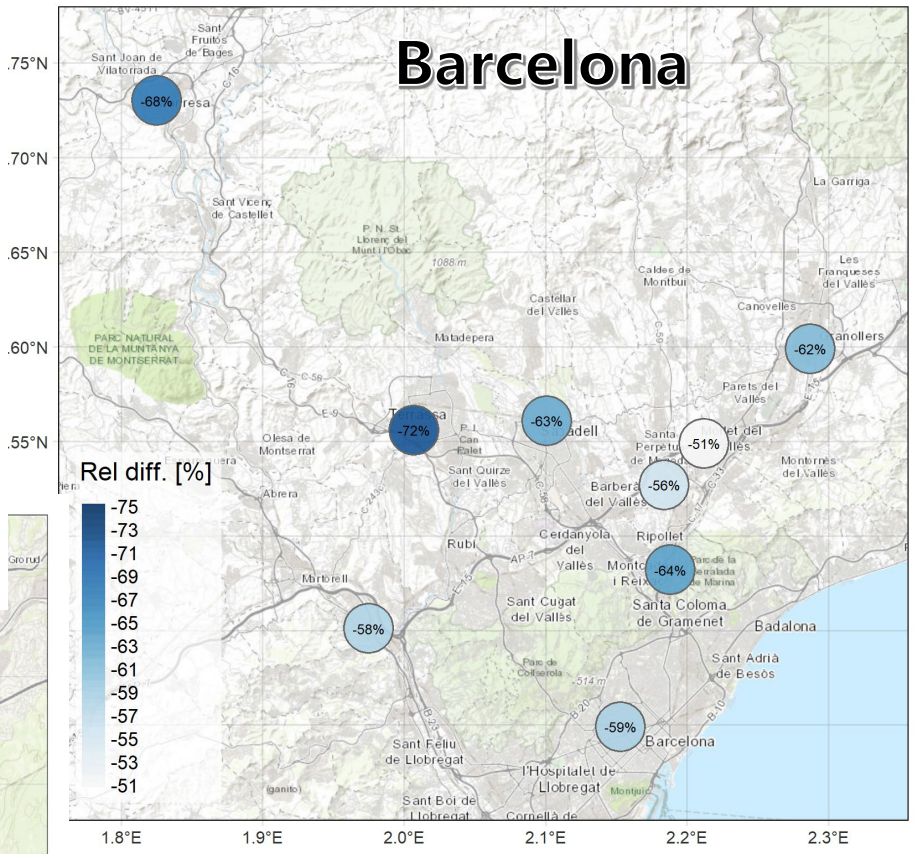
NO_2 change in selected cities







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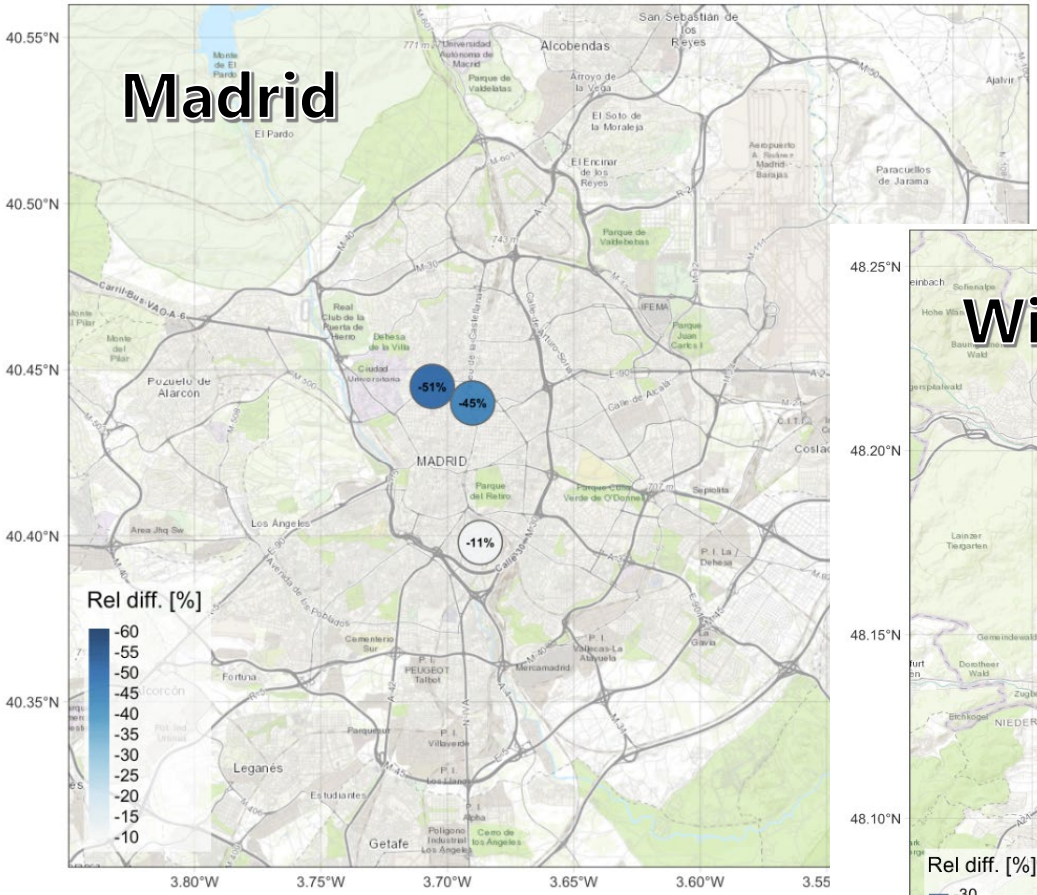
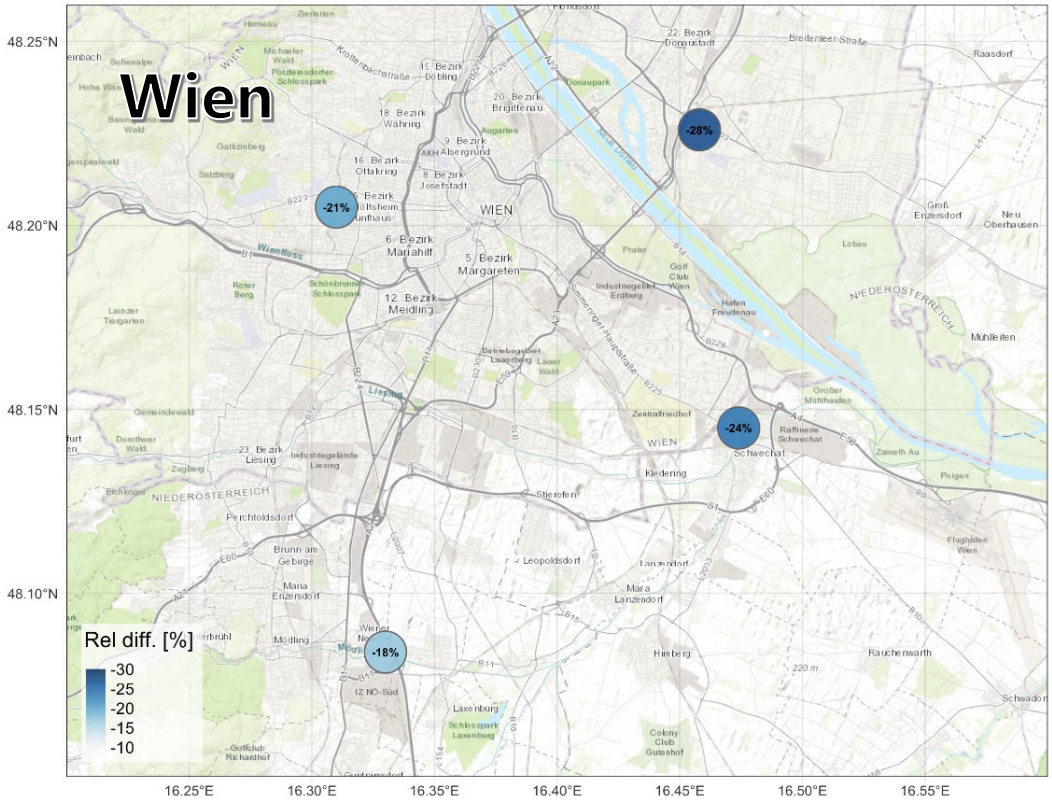
$PM_{2.5}$ change in selected cities





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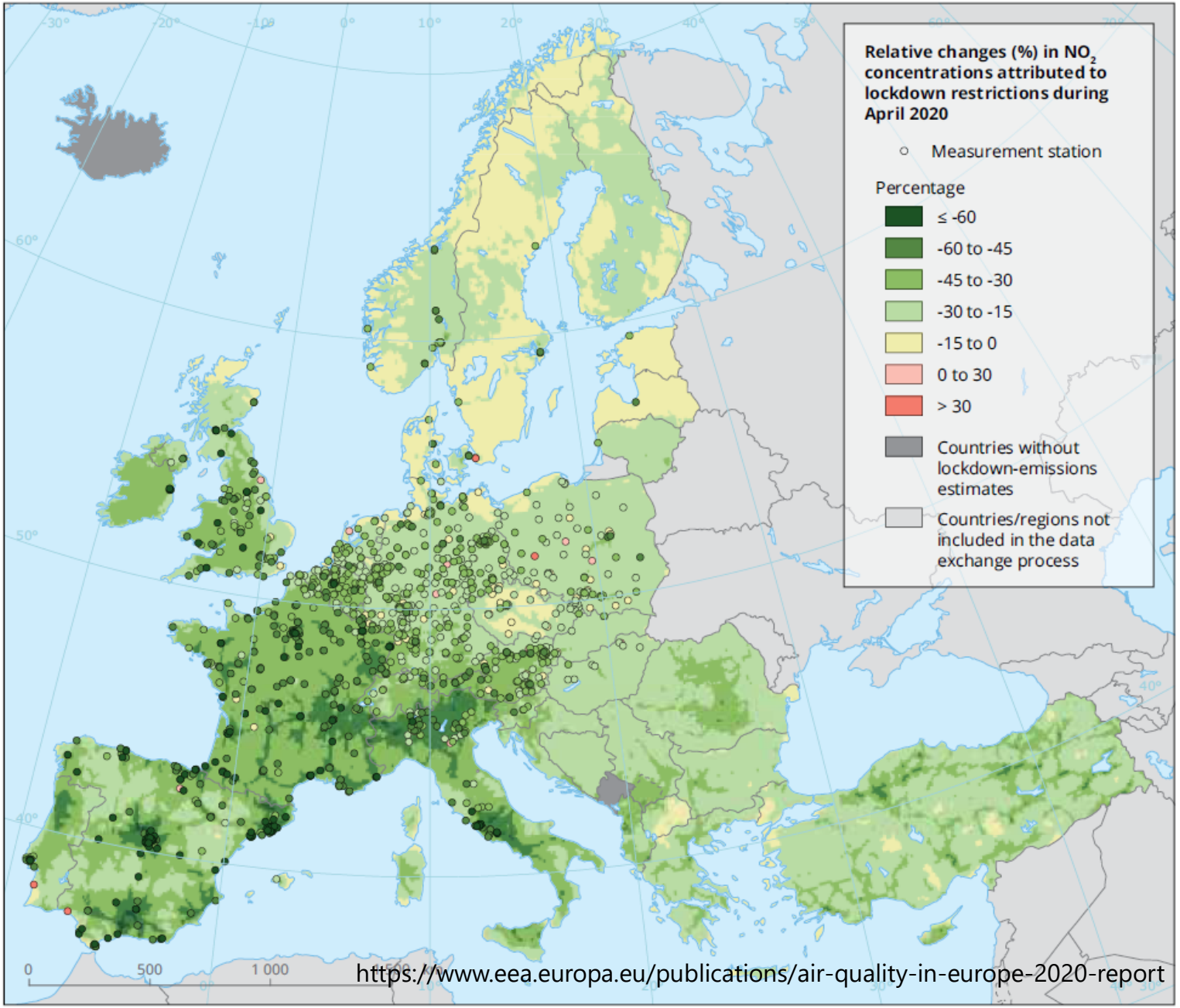
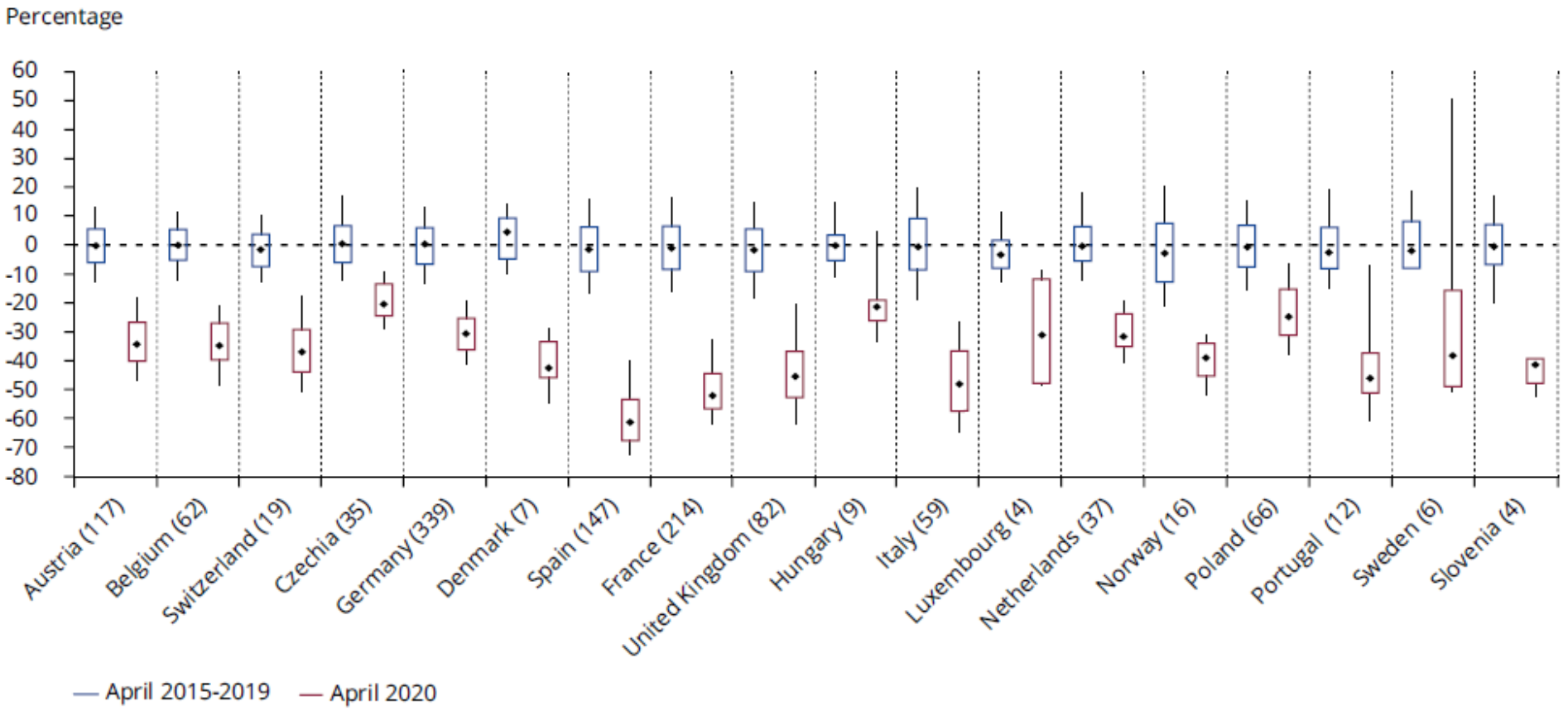
Changes in NO_2 conc. (%) due to lockdown, April 2020



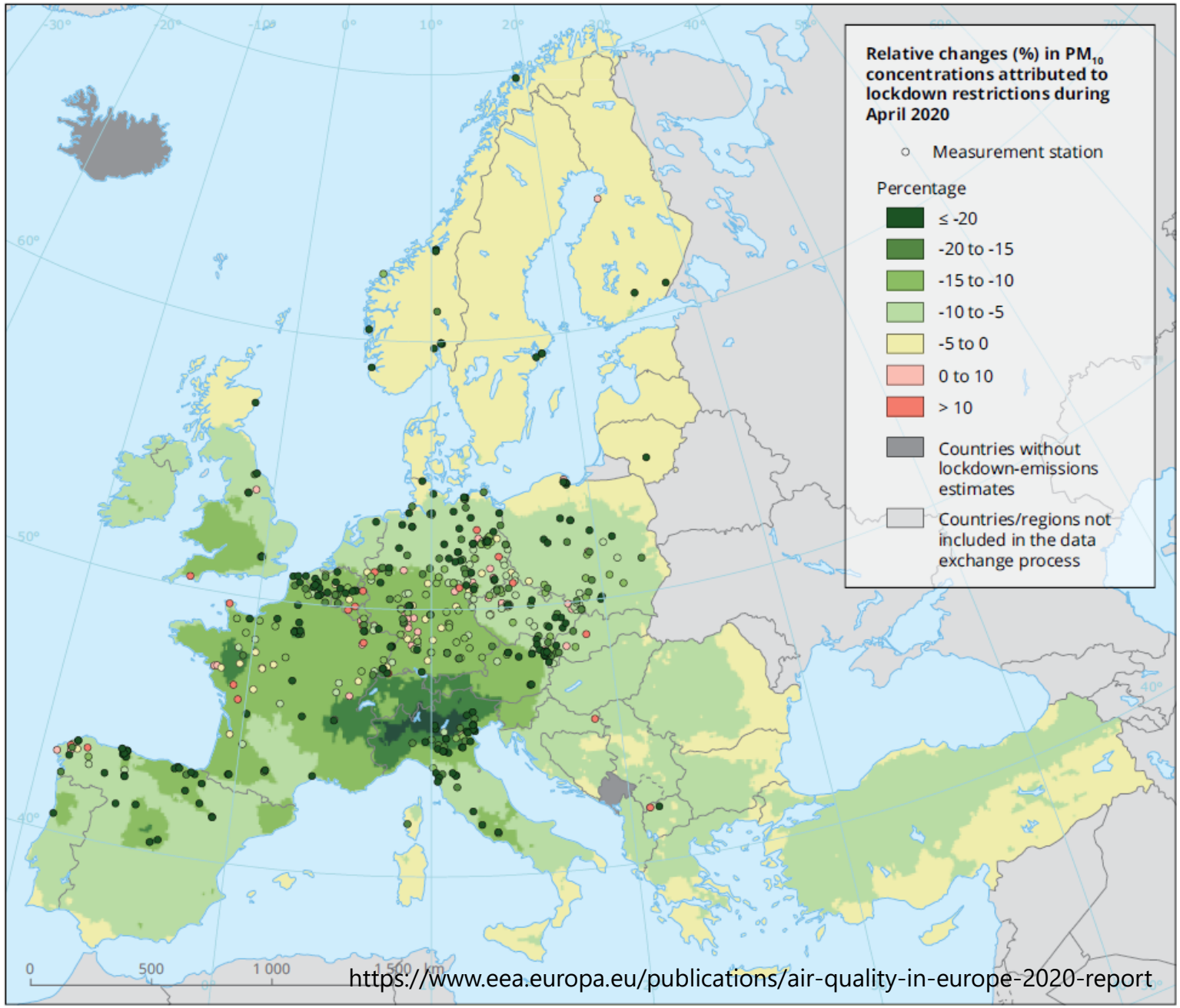
https://www.eea.europa.eu/publications/air-quality-in-europe-2020-report

Change in NO_2 concentrations (%)



https://www.eea.europa.eu/publications/air-quality-in-europe-2020-report

Changes in PM_{10} conc. (%) due to lockdown, April 2020



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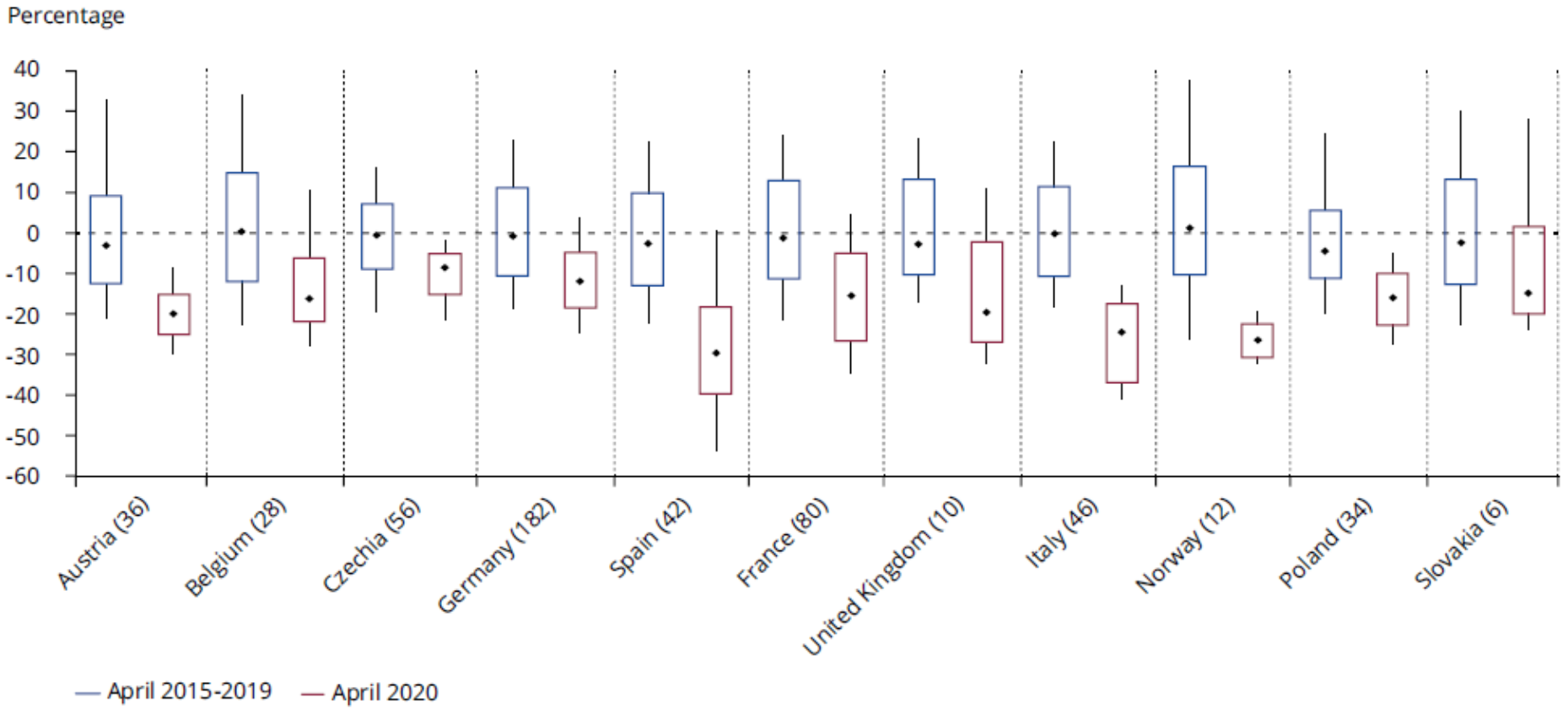
Change in PM_{10} concentrations (%)



https://www.eea.europa.eu/publications/air-quality-in-europe-2020-report

Summary

- The variability of meteorology must be taken into account in order to analyse reductions in concentrations due to lockdown
- All methods have uncertainties so we need a range of approaches to draw robust conclusions
- NO_2 concentrations have been greatly reduced due to reduced traffic during lockdown everywhere in Europe
- The variations are large between countries, cities and stations
- Particulate matter has not been reduced to the same extent as NO_2 during lockdown and has increased at some stations
- It is more difficult to quantify the causes of the changes in PM (multiple sources, chemical formation, long range transport)
- The analyses continue in 2021 for the full picture of 2020

Thank you!

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Article

Quantifying the Impact of the Covid-19 Lockdown Measures on Nitrogen Dioxide Levels throughout Europe

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Abstract: In this paper, the effect of the lockdown measures on nitrogen dioxide (NO_2) in Europe is analysed by a statistical model approach based on a generalised additive model (GAM). The GAM is designed to find relationships between various meteorological parameters and temporal metrics (day of week, season, etc.) on the one hand and the level of pollutants on the other. The model is first trained on measurement data from almost 2000 monitoring stations during 2015–2019 and then applied to the same stations in 2020, providing predictions of expected concentrations in the absence of a lockdown. The difference between the modelled levels and the actual measurements from 2020 is used to calculate the impact of the lockdown measures adjusted for confounding effects, such as meteorology and temporal trends. The study is focused on April 2020, the month with the strongest reductions in NO_2, as well as on the gradual recovery until the end of July. Significant differences between the countries are identified, with the largest NO_2 reductions in Spain, France, Italy, Great Britain and Portugal and the smallest in eastern countries (Poland and Hungary). The model is found to perform best for urban and suburban sites. A comparison between the found relative changes in urban surface NO_2 data during the lockdown and the corresponding changes in tropospheric vertical NO_2 column density as observed by the TROPOMI instrument on Sentinel-5P revealed good agreement despite substantial differences in the observing method.

Keywords: nitrogen dioxide; Covid-19; GAM; statistical modelling; generalised additive model; European Environmental Agency; lockdown

check for updates

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1. Introduction

The global Covid-19 pandemic in 2020 has led to major changes in society, the economy, and transportation worldwide. In Europe, the first cases of Covid-19 were detected by the end of January. In February, the number of incidents increased substantially in a few countries—Italy, France and Spain—and Italy was the first country in Europe to introduce restrictions on the population. Italy imposed a quarantine on more than 50,000 people in the northern part of the country on 22 February.

During March, most European countries introduced a full national lockdown, and most of these actions were taken mid-month. By 18 March, more than 250 million people were in lockdown in Europe, and by the beginning of April, 3.9 billion people or around half the global population were subject to complete or partial lockdown [1]. The global road transport activity was almost 50% below the 2019 average by the end of March, and commercial flight activity nearly 75% below 2019 by mid-April 2020 [2]. The lockdown restrictions were gradually lifted in the following weeks and months, varying substantially between the countries in Europe.

The reduced road transport and aviation led to reduced emissions of air pollutants and thereby lower levels of atmospheric pollutants, as documented by several European studies [3–11]. The quantification of this effect is, however, not trivial. First, weather patterns have a decisive influence on air pollutants' concentration through atmospheric

https://www.mdpi.com/2073-4433/12/2/131