A methodology to evaluate the Impacts of the COVID-19 lockdown on air pollution, with an application over Po Valley

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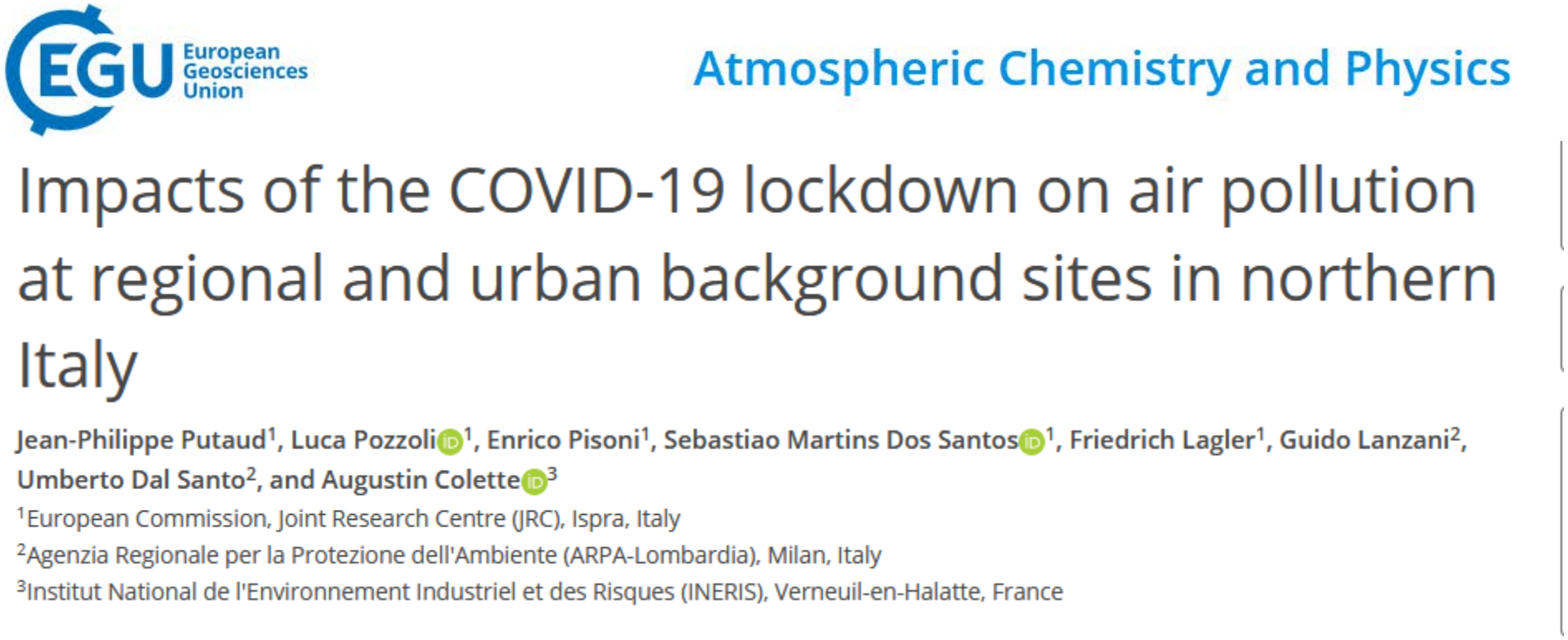
TFIAM Meeting, April 2021

Full paper at

- https://acp.copernicus.org/preprints/acp-2020-755/



European Geosciences Union

Atmospheric Chemistry and Physics

Impacts of the COVID-19 lockdown on air pollution at regional and urban background sites in northern Italy

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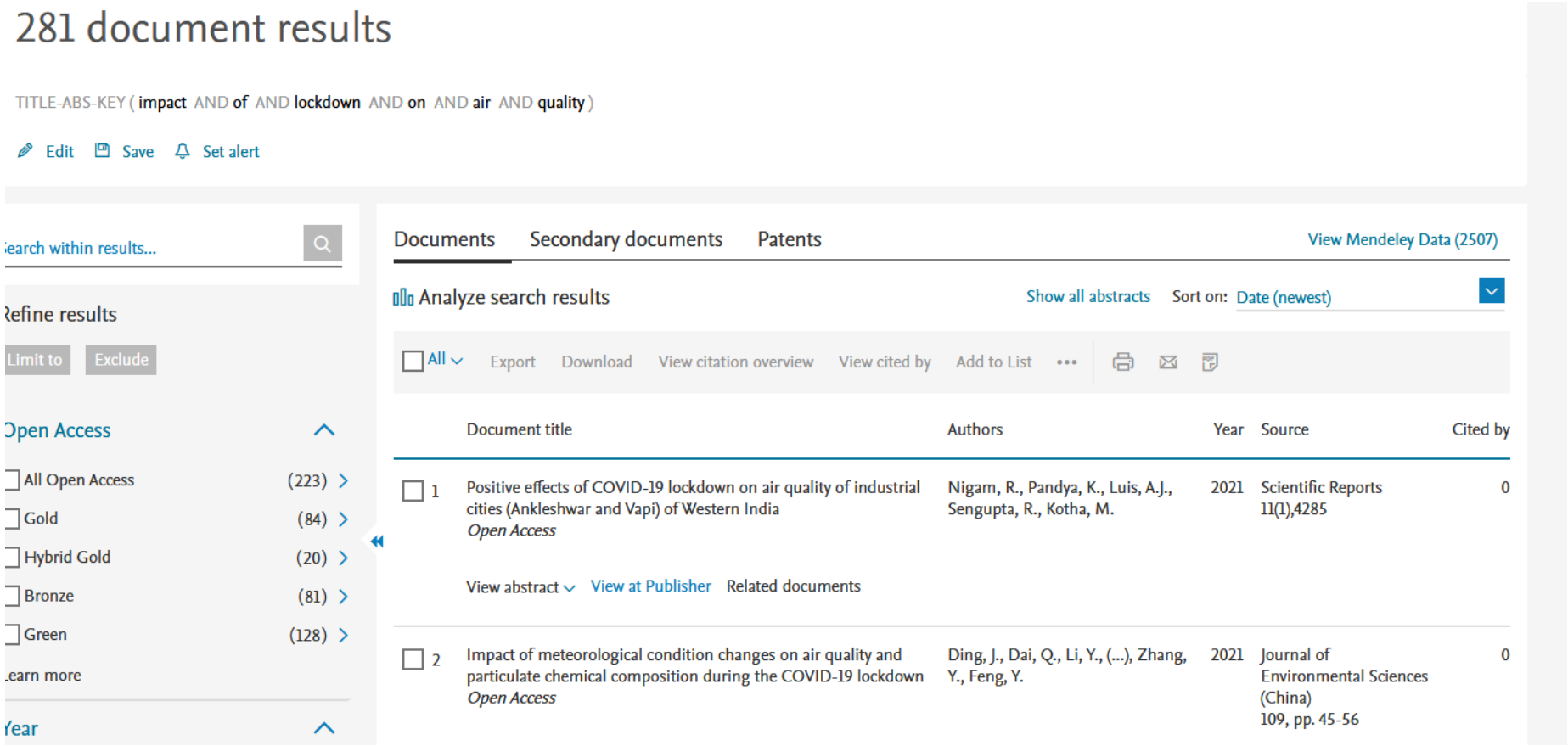
A lot of published paper on this topic...



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Why our paper

- Separating the impact of meteorology and emissions (using observations and models together)
- Need for comparing urban and regional background stations
- Idea: using availabla data
- Our methodology
  - Compare real measured concentrations (observations) and ‘expected concentrations’ (CAMS ensemble forecast)
  - Using additional ‘specific aerosol characterisation observations performed in Ispra’ to help interpretation (ACTRIS)

Methodology

Observed concentrations

- Regional background:
  - The European Commission Atmospheric Observatory (ECAtmO) operated in Ispra since November 1985. It contributes to EMEP , ICOS (Integrated Carbon Observation System) and ACTRIS (Research Infrastructure for the observation of Aerosol, Clouds and Trace Gases) for several years.
- Urban background:
  - regional authority stations, provided by regional authority in Lombardy

Focus on ECAtmo

- Available ‘specific aerosol variables’ in Ispra:
  - percentage in number of ultra-fine particles with mobility diameters between 15 and 70 nm as … **representative of particles emitted by primary sources**
  - aerosol light absorption Ångström exponent (AÅE)….commonly used **to apportion pollution particles between e.g. traffic and wood burning**. Traffic emitted particles (mainly from Diesel engines) have an AÅE close to 1, while particles from wood combustion have more variable AÅEs around.

Expected concentrations

- Based on CAMS ensemble forecast, runs ‘without the lockdown’

$$Exp = \frac{CAMS_{2020}}{CAMS_{2019}} Obs_{2019}$$

- Disadvantage of this approach is that Obs and Exp cannot be compared to each other on a daily basis … therefore 2020 Obs and Exp data were compared statistically for the 3 periods A (before), D (during), and P (after).

$$\bar{D} = mean\left(log\left(\frac{(Obs/CAMS)_{during\ lockdown}}{(Obs/CAMS)_{10\ Mars-25\ May\ 2019}}\right)\right), \bar{A} = mean\left(log\left(\frac{(Obs/CAMS)_{before\ lockdown}}{(Obs/CAMS)_{17\ Feb-9\ Mars\ 2019}}\right)\right), \bar{P} = mean\left(log\left(\frac{(Obs/CAMS)_{after\ lockdown}}{(Obs/CAMS)_{5-25\ May\ 2019}}\right)\right)$$

Application

Domain

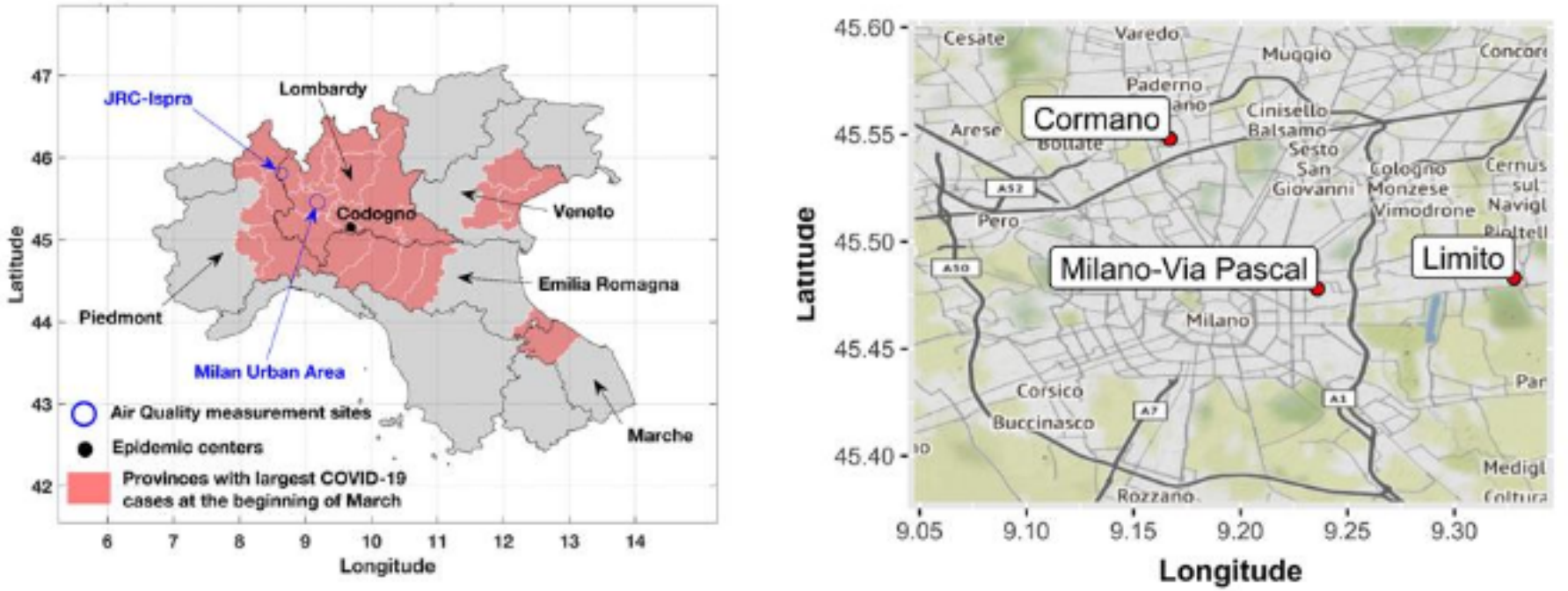


Figure 1: northern Italy areas impacted by the COVID-19 at the beginning of March 2020, and location of the air pollution measurement sites in Ispra and Milan considered in this study. Right hand panel: © OpenStreetMap contributors 2020. Distributed under a Creative Commons BY-SA License.

Idea on pressure change

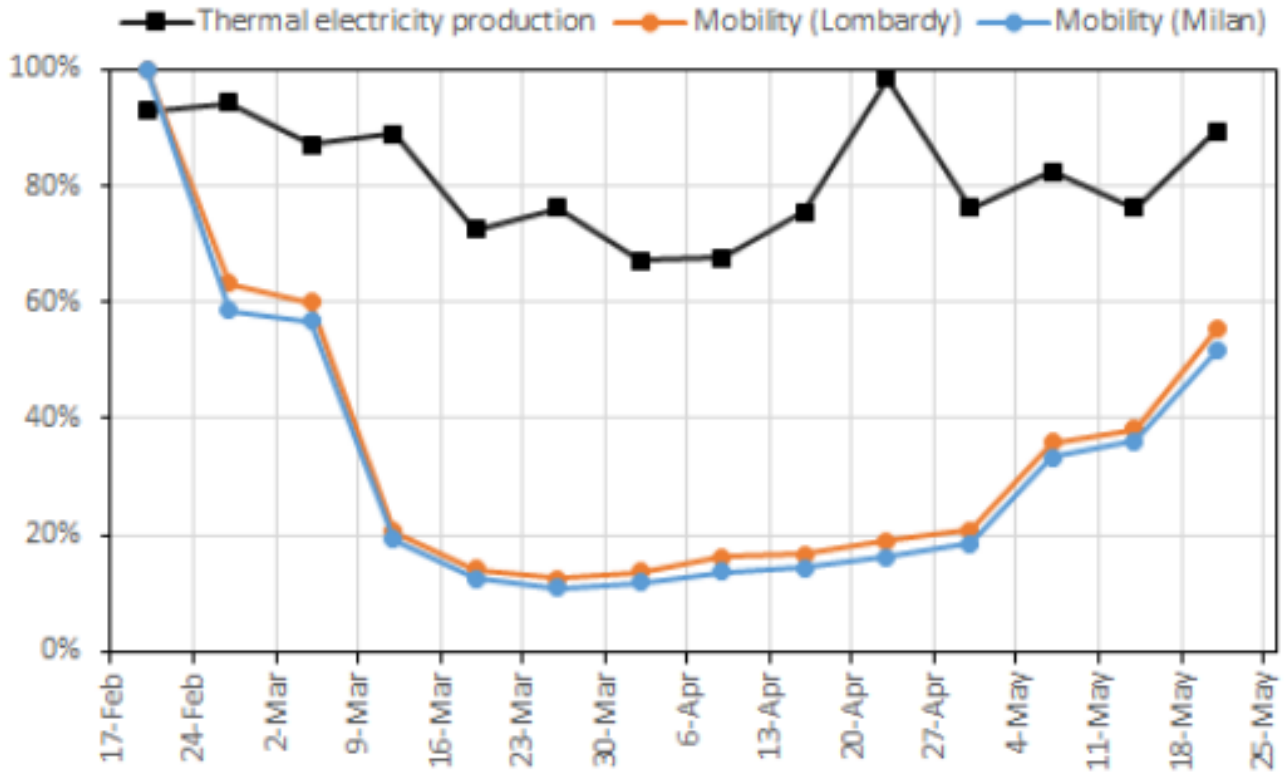
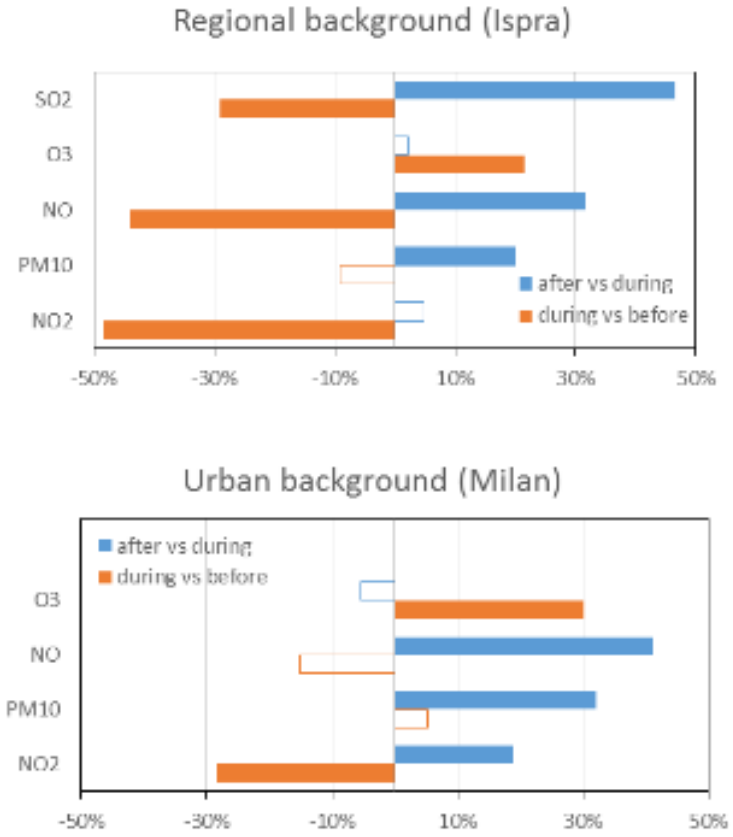


Figure 2: Variations in activities resulting from lockdown measures (2020). Percentages are calculated in comparison with 2019 data for thermal energy production (source: www.terna.it) and in comparison with data from the third week of February 2020 for mobility data (source: www.apple.com/covid19/mobility).

Changes in observed / expected concentration



Results show

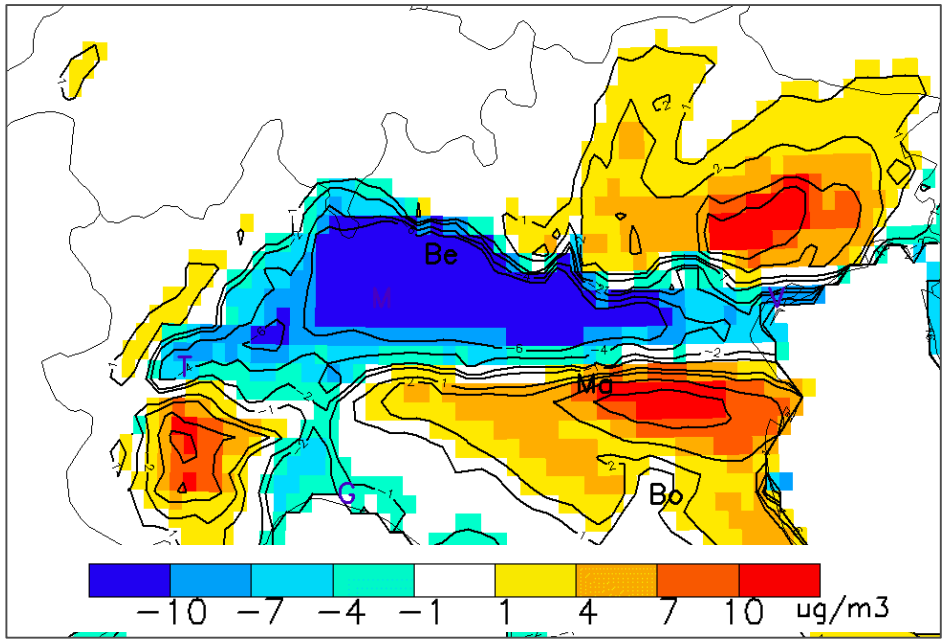
- NO_2 concentrations decreased by −30 % and −40 % on average at the urban and regional background sites, respectively.

- PM_{10} concentrations were not significantly affected by lockdown measures. Possible reasons:
  - decreases in emissions from traffic being compensated for by increases in emissions from domestic heating
  - changes in the secondary aerosol formation regimes

The implementation of the lockdown measures also led to an increase in the highest O_3 concentrations, resulting from reduced titration of O_3 by NO -> increased oxidative capacity -> increased formation of ammonium nitrate in PM10

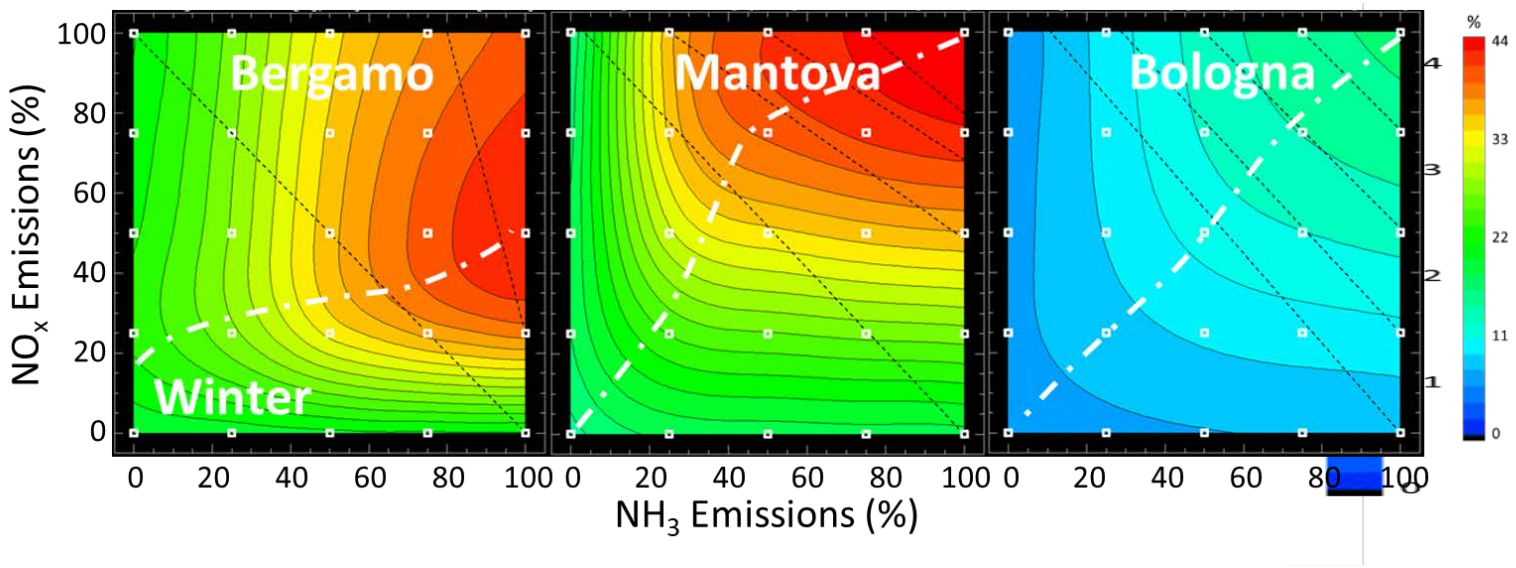
Negative responses to NO_x emission reductions

EMEP NO_x-NH_3 chemical regimes (winter)



$P^{25\%}_{NO_x} - P^{25\%}_{NH_3}$ (unit: µg m^{-3})

$PM_{2.5}$ (NO_x-NH_3 isopleths - winter)



P. Thunis, A. Clappier, M. Beekmann, J. P. Putaud, C. Cuvelier, J. Madrazo, A. de Meij, 2021: Non-linear response of $PM_{2.5}$ to changes in NO_x and NH_3 emissions in the Po basin (Italy): consequences for air quality plans, Atmospheric Chemistry and Physics (under review). https://doi.org/10.5194/acp-2021-65

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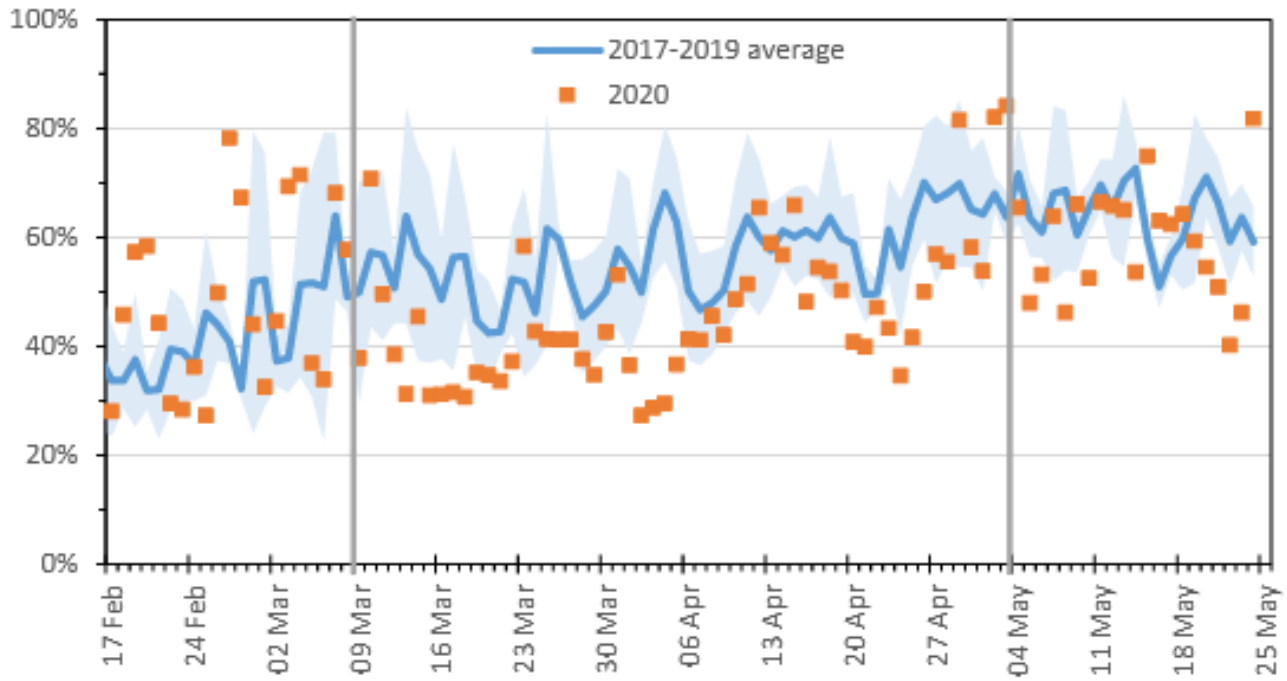
Percentage in number of tiny particles

- The decrease in emissions from local traffic indicated by the drop in the percentage of the smallest particles is the most probable cause for the decrease of NO related to the lockdown measures in Ispra



Absorption Ångström exponent

- Clear increase in the AÅE average between 9 March and 4 May 2020 compared to the corresponding period in 2017 -2019 shows a change in particle sources related to lockdown measures.
- The analysis suggest a -45% reduction in aerosol from traffic (and a concomitant + 45% increase in aerosol from wood combustion) during that period

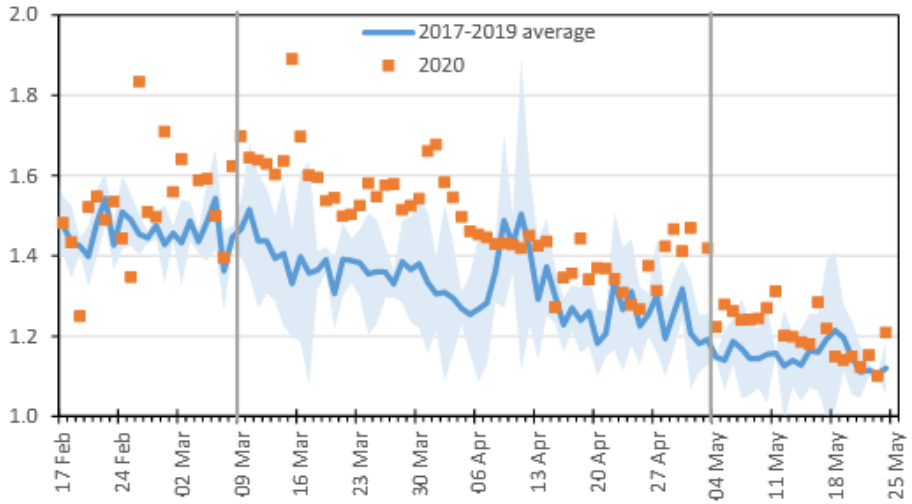


Figure 5: Aerosol light absorption Ångström exponent (AÅE) in 2020 (dots) compared to its 2017 – 2019 average (lines). The shaded area represents ± 1 standard deviation of the average. Vertical lines indicate the beginning and the end of the lockdown period.

Conclusions

- We propose a methodology to evaluate the lockdown impact, using
  - Measures observations VS expected concentrations
- Application on Po Valley
  - Pollution hot spot and first EU COVID cluster (lockdown: 9th March to 4th May)
  - Statistically significant impact on NO2
  - PM10 not affected
- Next step: extension to other EU cities

Thank you

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