PulVirus

3rd EPCAC Meeting:
Part 6: What lessons can be learned from emission reductions during corona lockdown?

The effects of lockdown measures on air quality in Italy based on model simulations

Ilaria D'Elia and Massimo D'Isidoro (ENEA)

The Project PULVIRUS

- Scientific alliance between ENEA, the Italian National Institute of Health (ISS) and the National System for Environmental Protection (ISPRA+SNPA), to investigate the debated link between air pollution and the spread of the pandemic, the physical-chemical-biological interactions between fine particulate matter and viruses, the effects of the "l*ockdown*" on air pollution and greenhouse gases in Italy;
- Start 24 June 2020 to 23 June 2022;
- 6 Working Packages:
  - WP1: Analysis of the effects of physical distancing measures during the period of the COVID 19 pandemic: what the Italian monitoring stations say;
  - WP2: The effects of lockdown measures on air quality in Italy based on model simulations;
  - WP3: Characterization of the particulate matter chemical composition and size distribution;
  - WP4: Effect of the COVID related emission reductions on greenhouse gases;
  - WP5: Physical-chemical-biological interactions between fine particles and viruses;
  - WP6: Recommendations on air particulate samples treatment, preliminary evaluations for the development of an early warning model and training in the emergency context.
- More information available at https://www.pulvirus.it/ (in Italian but it will be soon translated in English).

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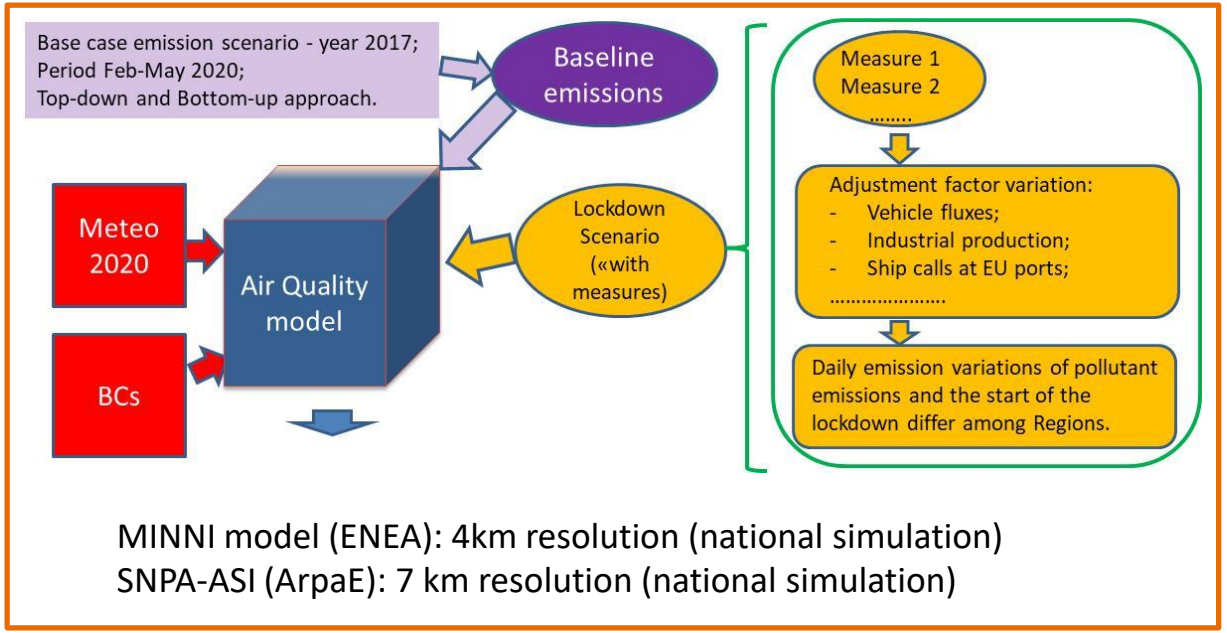
The effects of lockdown measures on air quality in Italy: the methodology

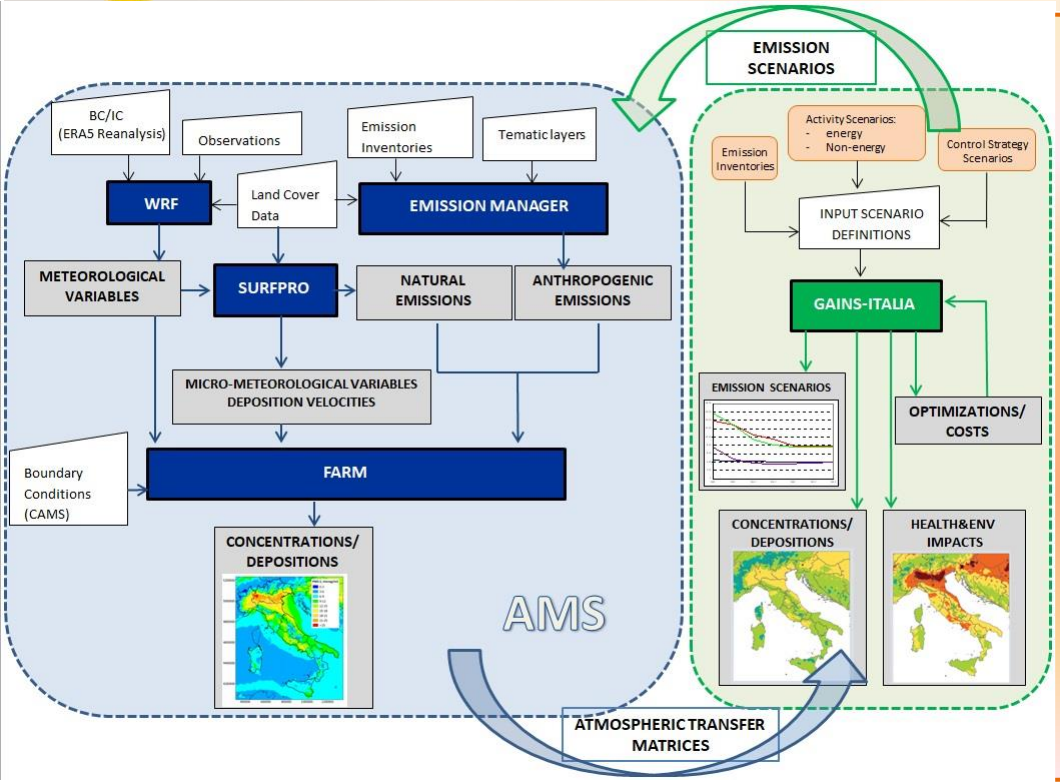
The aim of the project is to understand

- how air quality models reproduce significant emission variations in a very short period;
- the emission variations from specific sectors affected by the COVID-19 restrictions;
- the effect on secondary pollutants.



MINNI model (ENEA): 4km resolution (national simulation)
SNPA-ASI (ArpaE): 7 km resolution (national simulation)

The MINNI model setup

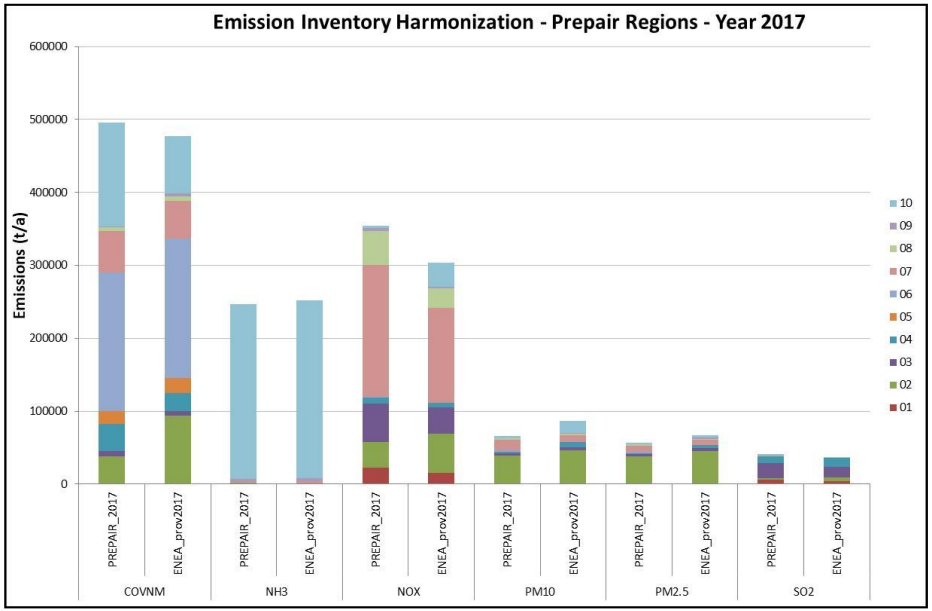


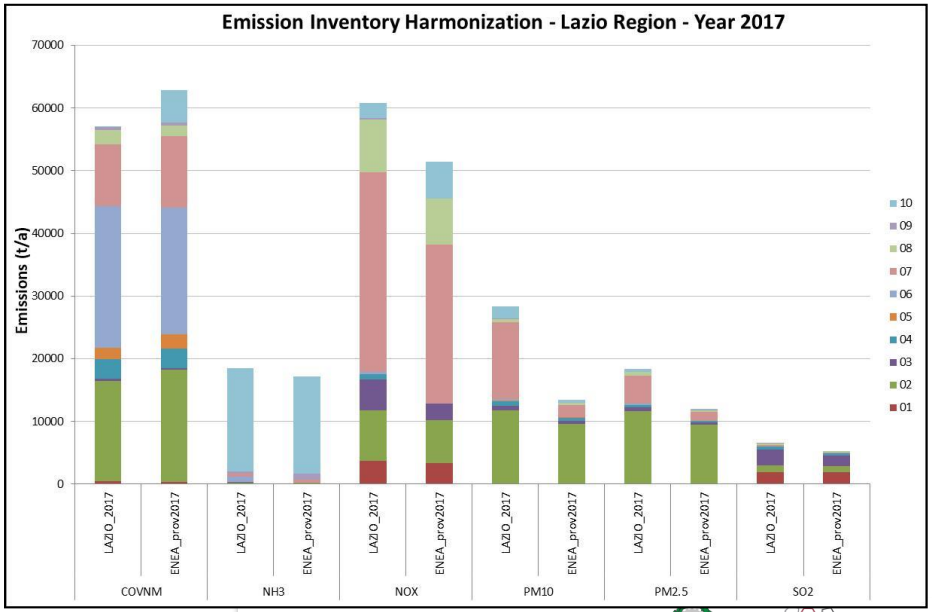
Two air quality simulations: BASE and LOCK;
Period: 1 February – 31 May 2020;
MINNI model: 4km resolution;
MINNI model:

- BC from CAMS Covid Simulation base and lockdown (MINNI_CAMS details:
  - Emissions -> CAMS_REG_APv4.2 – year 2017;
  - meteo IFS;
  - base and lockdown scenario with lockdown starting the 21st of February 2020).
- Meteo: WRF (year 2020), two-way nesting (12km -> 4km) and ERA5 as BC;
- BVOC: MEGAN model.

The base case emission scenario

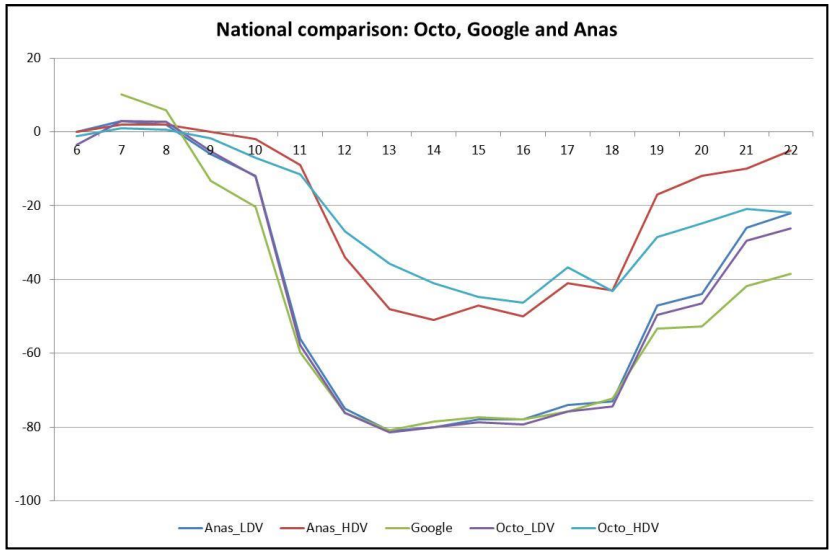
- Base case emission scenario - year 2017
- Harmonization with the available regional emission inventories

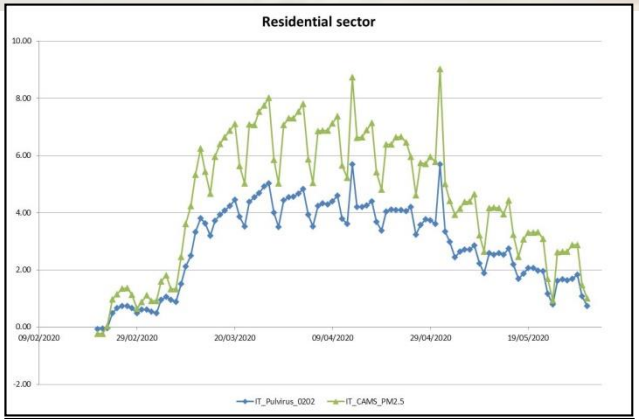


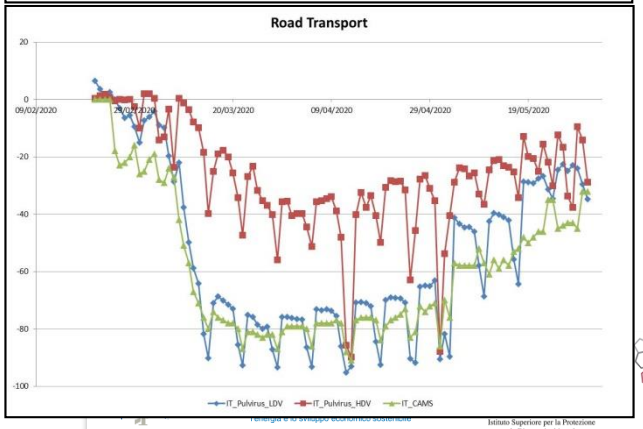


The lockdown emission scenario

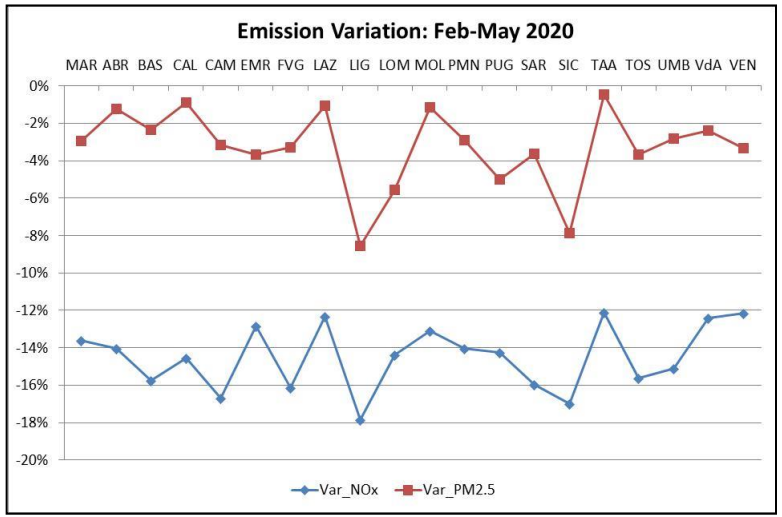
- Selected adjustment factor variations for each sector
- Comparison with regional and European variations
- Daily/weekly or monthly profiles

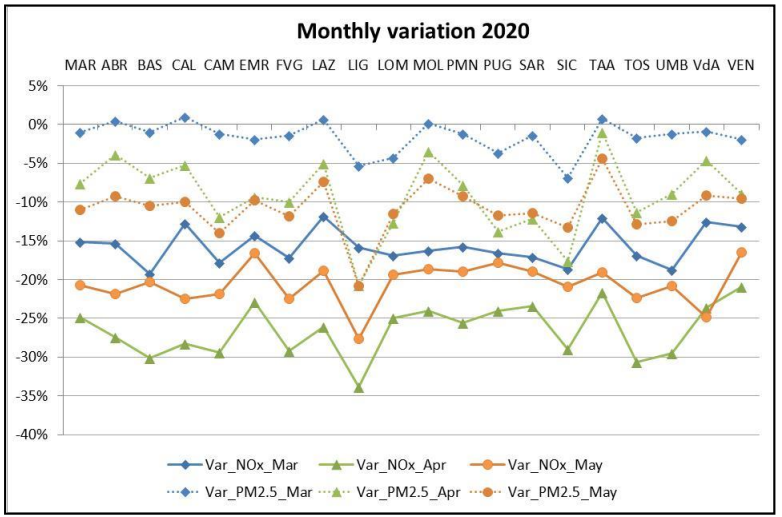






Emission Variations: LOCK vs BASE





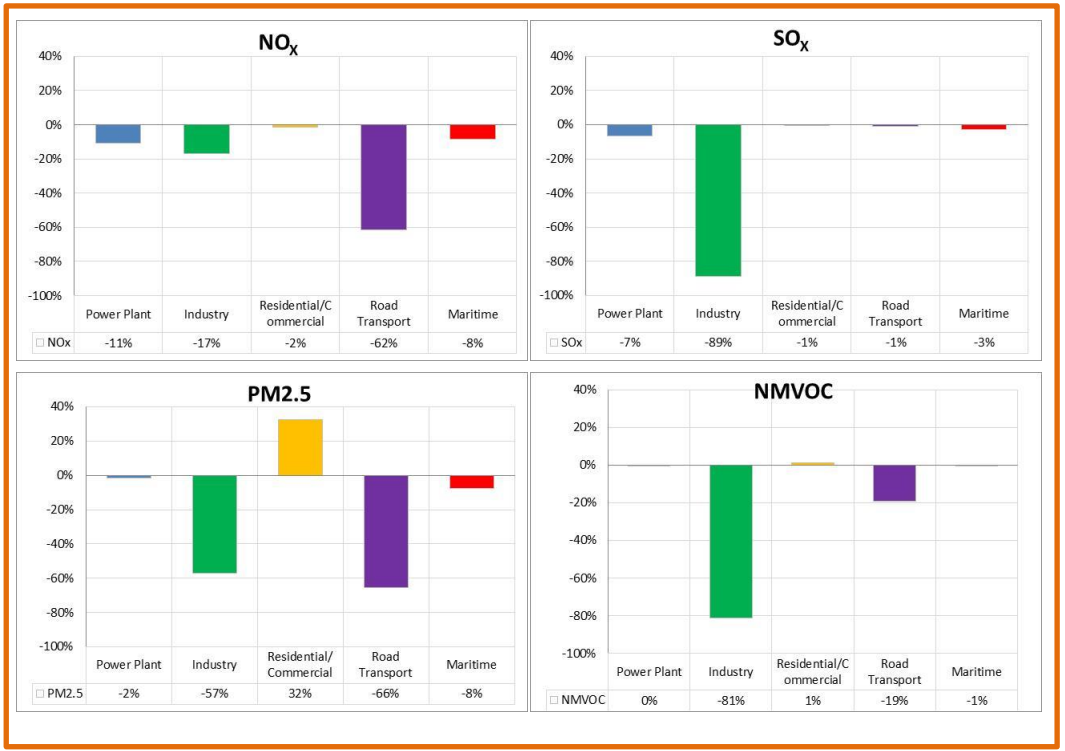
In the entire period:

- NOx Emission Reductions vary from 12% to 18%;
- PM2.5 Emission Reductions vary from 0.5% to 8%

Monthly variations:

- NOx highest reductions in April;
- In some Regions PM2.5 increases in March

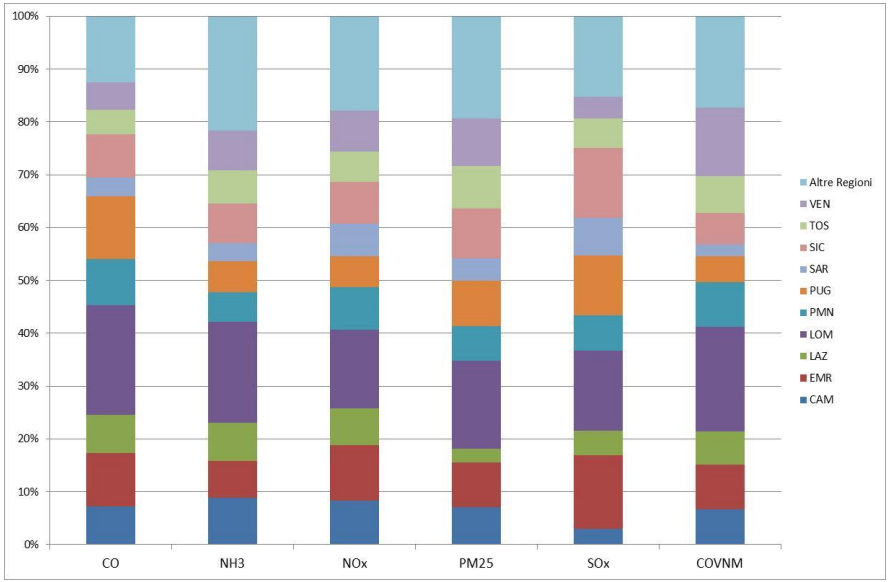
Emission Variations: LOCK vs BASE



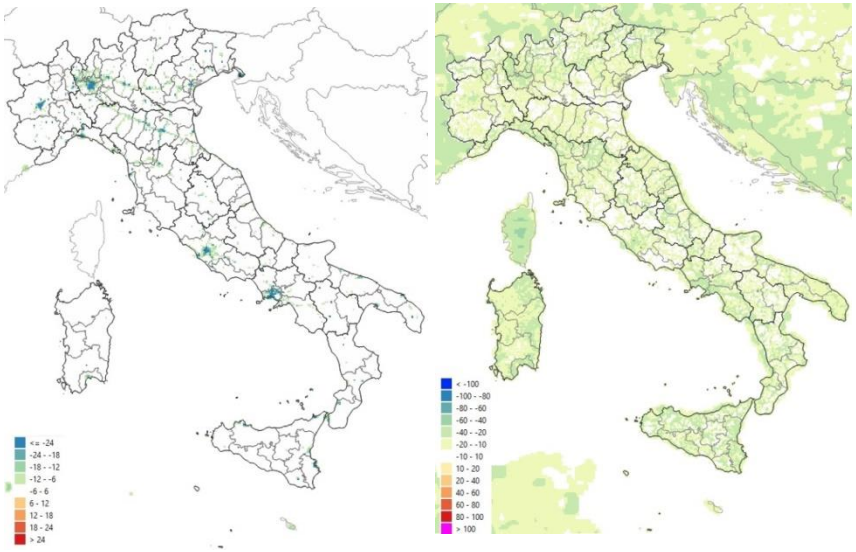
Sectoral Contribution, period Feb – May 2020:

- Road Transport: NO_X (-60%), $PM_{2.5}$ (-66%)
- Industry: SO_X (-90%), NMVOC (-80%);
- Maritime: NO_X (-8%), SO_X (-3%);
- Residential: $PM_{2.5}$ (+32%);
- No emission variation in the agricultural sector so no significant NH_3 emission reductions.

Emission Variations: LOCK vs BASE



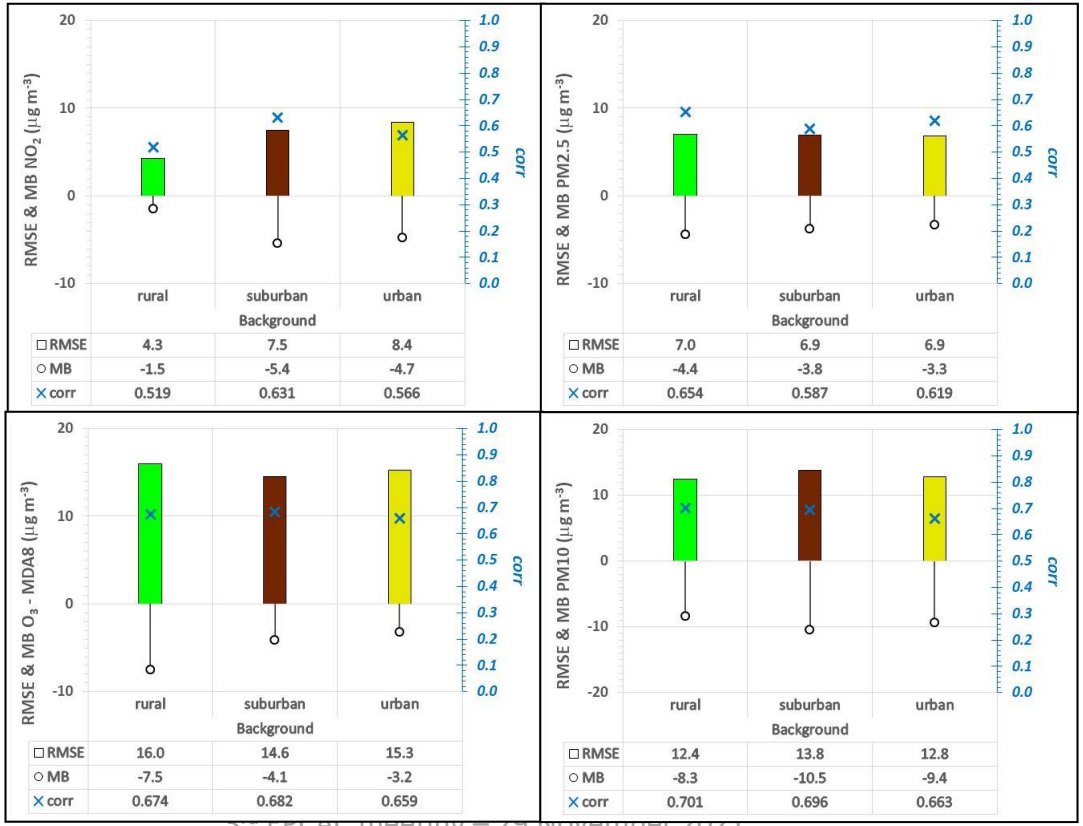
Lombardy region higher contribution reduction for all the polls (varying form 15% to 21%) then Emilia Romagna.



NO_X Emissions: absolute variation (ton/cell - sx) and % (dx) for the whole period

Maps available for all the pollutants by day, month and for the entire period.

MINNI lockdown and observations



Score calculated in the period Feb – May 2020 for LOCK simulation:

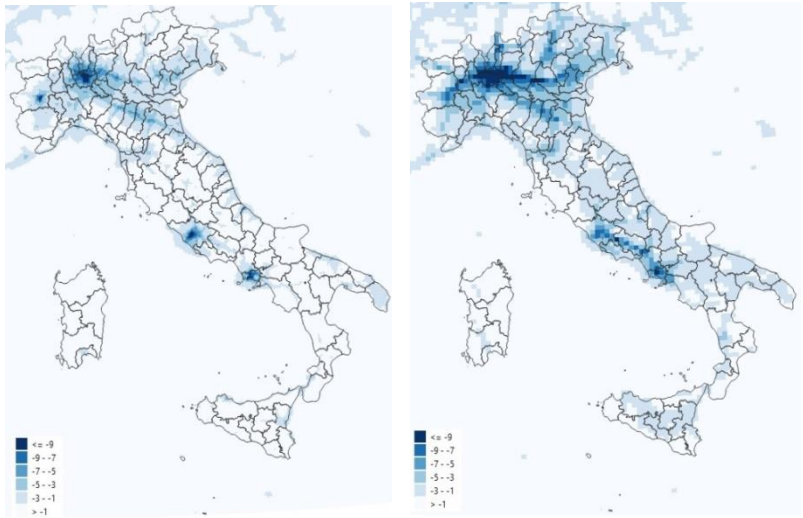
- daily values for NO_2 and PM
- MDA8 (maximum daily 8-hour average concentration) for O_3

Same model performances of other MINNI simulations

Score calculated for each station, per pollutant, by month and climatic zone.

MINNI lockdown and CAMS lockdown: variation in NO_2 concentrations

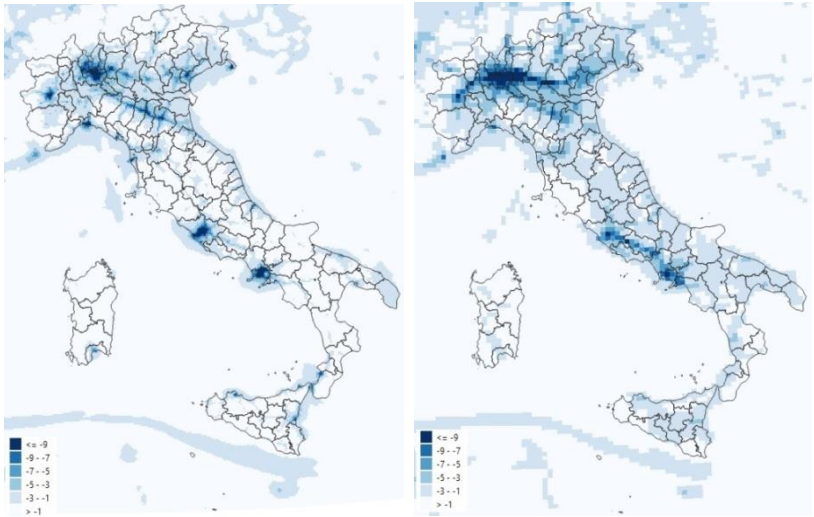
March 2020



MINNI in Pulvirus (4km)

MINNI in CAMS (10 km)

April 2020

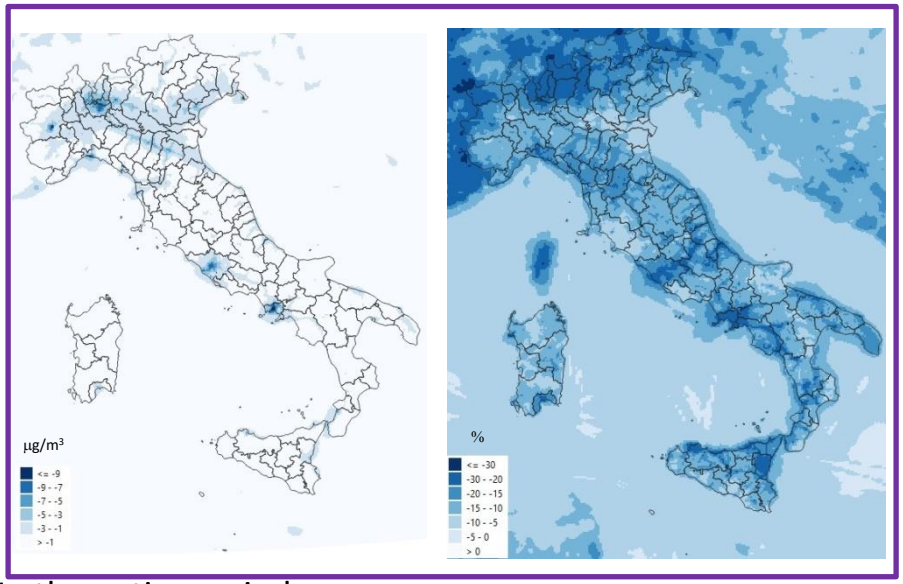


MINNI in Pulvirus (4km)

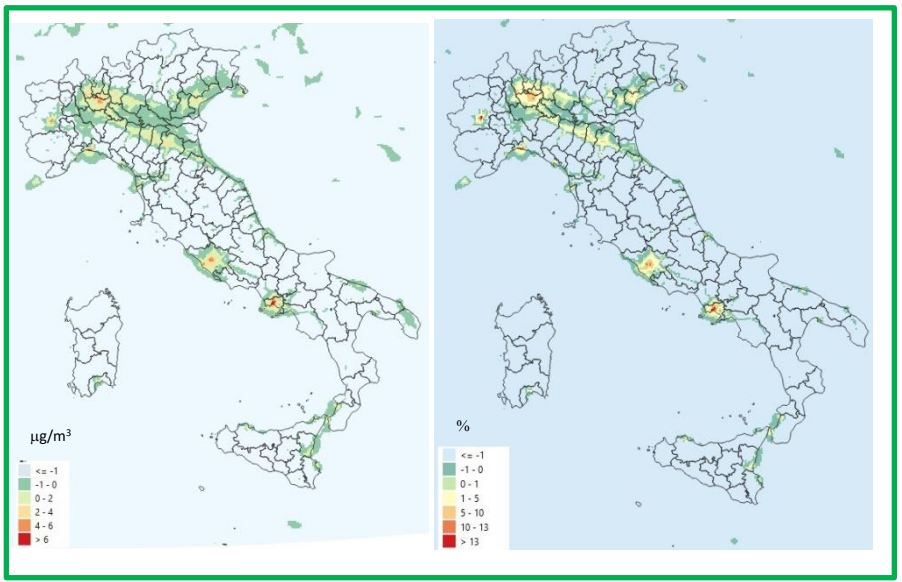
MINNI in CAMS (10 km)

MINNI lockdown: concentration variations – period Feb – May 2020

NO_2



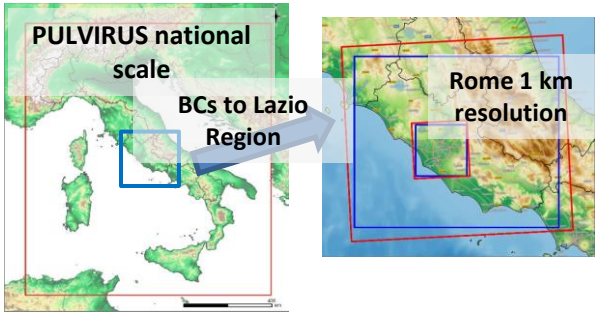
O_3



In the entire period:

- NO_2 concentration reductions vary from 1 to 9 µg/m³ (3% to 30%);
- O_3 concentration increases in urban areas till 13% (5-6 µg/m³);
- PM does not show significant variations.

MINNI simulations as BC to other models: Lazio and Rome simulations



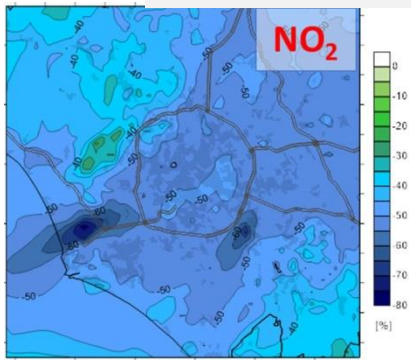
Finardi et al., 2021. GAW Symposium 2021
https://hopin.com/events/gaw-syposium-2021#schedule

Credits by ARIANET e Arpa Lazio.

ARPALAZIO
AGENZIA REGIONALE PROTEZIONE AMBIENTALE DEL LAZIO

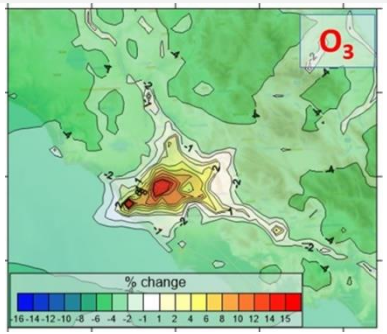
ARIANET

April 2020 monthly mean concentrations: % reduction due to 2020 vs BASE emissions



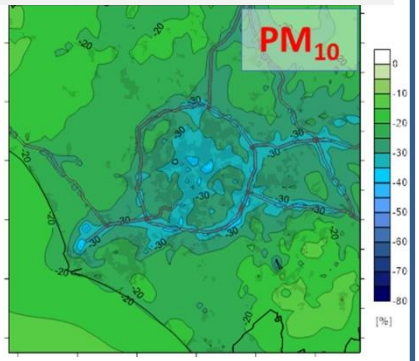
NO_2 concentration change

Mean predicted NO_2 reduction for April 2020 ranged between 40 and 55% in the central part of Rome city, and from 50 to 65% in the outer part of the conurbation, comparing with an average 45% decrease estimated from local observations in the city centre and 60% decrease in the outskirt.



O_3 concentration change

Mean predicted O_3 concentration for April 2020 increases inside the conurbation and near the major roads, while it decreases at rural background locations



PM concentration change

Mean predicted PM_{10} concentration reduction for April 2020 reached 30-35% in the city centre and nearby the major roads, and a 20-30% decrease in the peripheral areas. Observation based analysis indicated a 27% average decrease in the city centre and a 13% decrease in the outskirts.

Indications for Air Quality Management

Preliminary results confirm the predictable effectiveness of mobility measures to reduce the urban population exposure to NO_2 concentration and foster the strengthening of public transport, as well the implementation of electric and green mobility. Otherwise, the reduced impact on PM_{10} and $PM_{2.5}$ of the emission changes related to covid-19 lockdown highlights the need to target other emission sectors than mobility (e.g. biomass burning for house heating, agriculture,…) and the need of policies at regional/continental level. A wide diffusion of electric mobility cannot be expected to be the key solution to PM pollution even due to non-exhaust emission contribution persistence.

Evaluation of the impact of reducing emissions on environmental concentrations of greenhouse gases

ENEA manages the Stations for Climate Observation of Lampedusa and Piano Battaglia (1650 m), both part of the Regional network of Global Atmosphere Watch of WMO:

- Lampedusa Station has a series of CO_2 and other greenhouse gasses data from the 1992. It is part of the European Research Infrastructure *Integrated Carbon Observation System;*

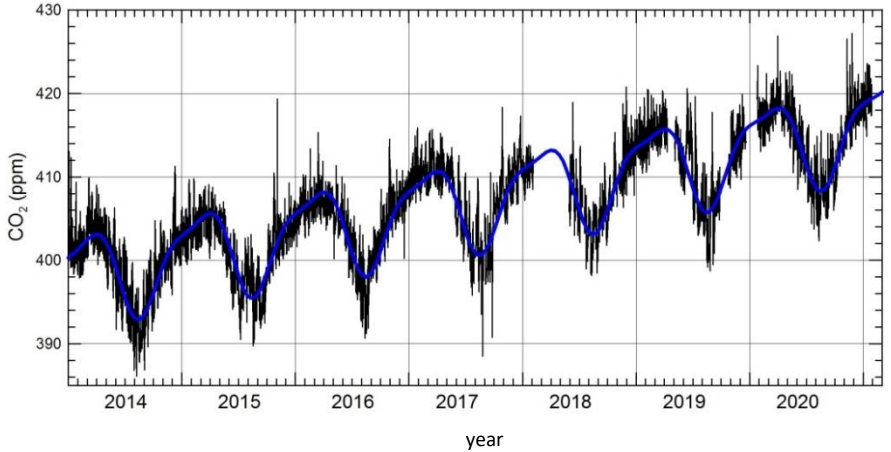
More details on the site and all the installed instruments are available at https://www.lampedusa.enea.it/

- Station of Piano Battaglia which has a weekly series of CO_2 data from the 2005.

In the frame of the project PULVIRUS in situ continuous greenhouse / aerosol measurements are strengthened at both the ENEA Stations to answer to the questions: ***if* and *to what extent* the change in anthropogenic CO_2 emissions associated with the *lockdown* measures could be reflected in the background atmospheric concentration.**

Evaluation of the impact of reducing emissions on environmental concentrations of greenhouse gases

First results:



Evolution of the hourly concentration of atmospheric CO_2 measured in Lampedusa from 2014 to Feb 2021 (black line; while the blue line is the regression curve that takes into account annual and semiannual cycle).

- annual growth of 2.6 ppm / year
- amplitude of the annual cycle of 10.5 ppm
- amplitude of the semiannual cycle of 3.0 ppm

- No CO_2 concentration reductions in Lampedusa site linked to CO_2 emission reductions during the *lockdown* (estimated on a national level in 9.8% in 2020 respect to 2019);
- The CO_2 emission variation rate that should be kept in the next decades to limit global warming to 1.5°C is around 7.5%.

Contact person: giandomenico.pace@enea.it

Conclusions

In the simulated period (Feb-May 2020) on a national level:

- Total NO_X emission reductions vary from 12% to 18%;
- Total $PM_{2.5}$ emission reductions vary from 0.5% to 8%;
- NO_2 concentration reductions vary from 1 to 9 $\mu g/m^3$, higher in urban areas
- O_3 concentration reductions in rural areas and increases in urban areas (to 13%);
- PM concentrations (not shown): small variations, more relevant in the Po Valley.

- Effects on secondary pollutants and PM composition should be carefully studied.
- Reduction measures should be carefully selected: target more sectors (not only mobility, but also **agricultural**, residential…) and integrate measures on a different scales.
- Integrated Approach needed to evaluate the different impacts.
- First analyses do not show CO_2 concentration reductions at Lampedusa site.

THANK YOU FOR YOUR ATTENTION

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