Effetti delle Misure di Contenimento della Pandemia di COVID-19 sulle Concentrazioni di NO_2 e Black Carbon nei pressi di un'Importante Autostrada Italiana

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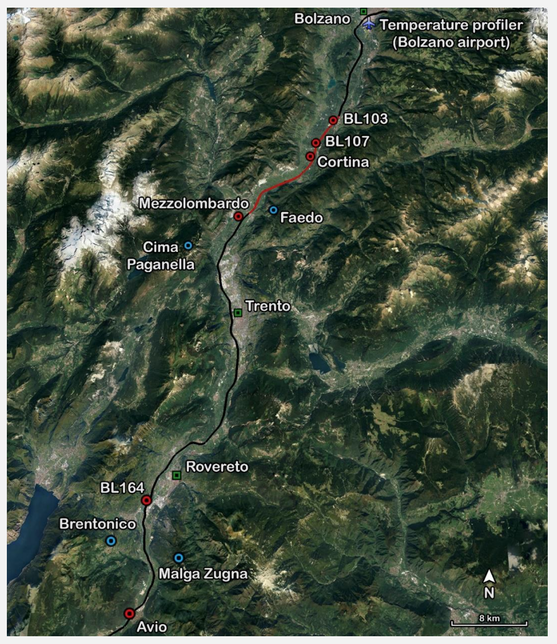
Introduction

During the first half of 2020 the Italian government imposed several restrictions to limit the spread of the COVID-19 pandemic, leading to a drastic reduction of the traffic and, consequently, of the traffic-related emissions. The aim of this study is to evaluate the effects of these restrictions on pollutant concentrations close to a stretch of the Italian A22 highway in the Alpine Adige valley. The analysis focuses on measured concentrations of nitrogen dioxide (NO_2) and black carbon (BC). Since atmospheric concentrations of pollutants depend both on emissions and on meteorological conditions, which can mask the variations in the emission regime, a random forest algorithm is also applied to the measured concentrations, to better evaluate the effects of the restrictions on emissions. The results highlight a drop of NO_2 concentrations at the beginning of the lockdown period, followed by a slow and partial recovery in the following months. Considering BC, the biomass burning component (BC_{bb}) was not significantly affected by the lockdown, while concentrations of the fossil fuel component (BC_{ff}) showed an abrupt decrease.

Air Quality Measurements



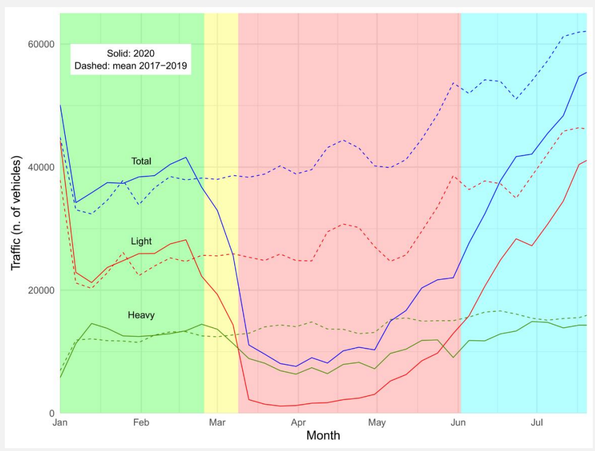
Study area along with air quality and meteorological stations used in this study.

Data from six air quality stations at different distances from the A22 highway are analysed. Three of them (BL103, BL107 and BL164) are located close to the highway, at a distance of about 10 m from the traffic centreline. Avio is located 16 m from the highway centreline and thus it is still representative of traffic-related emissions. The other two stations (Mezzolombardo and Cortina), are located a few hundred metres from the highway, far from major pollutant sources, and their measurements are used to assess the effect of the lockdown measures on background pollutant levels in the rural areas of the valley floor.

Traffic Data

The number of vehicles transited on the highway was provided by measurements performed with an inductive loop. These data allow to quantitatively evaluate the effect of COVID-19 restrictions on the highway traffic. Four periods with different traffic conditions were derived, comparing traffic in 2020 with the three previous years:

- **1 January – 24 February**: light and heavy vehicles increased by 9% and 4%.
- **25 February – 8 March**: light vehicles decreased by 16%, while heavy traffic increased by 4%.
- **9 March – June**: traffic decreased by 38% for heavy-duty vehicles and by 85% for light vehicles.
- **3 June – 20 July**: light and heavy vehicles decreased by 30% and 16% respectively.



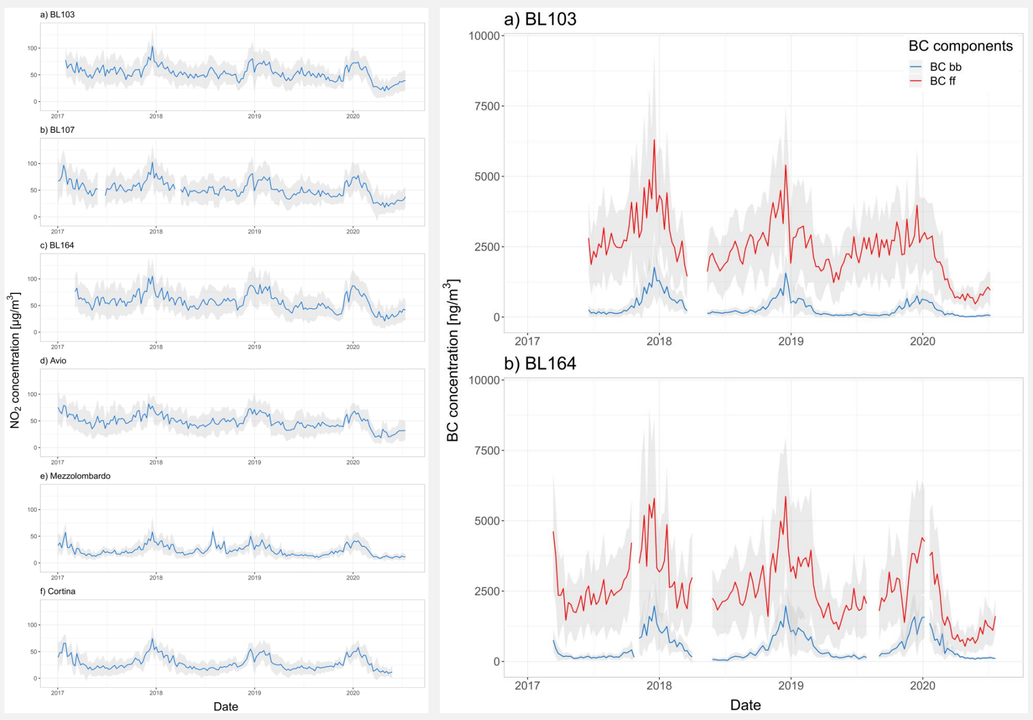
Traffic data for 2020 and 2017-2019. Background colours indicate the different periods.

Random Forest Algorithm

The predictive and meteorologically normalised time series are obtained exploiting the *rmweather* R package, a random forest code that uses the machine learning decision tree technique for training and predictions. The procedure used in this study is described in the following:

1. **Dataset splitting**: the dataset is divided into training (80% of the days) and testing sets (20% of the days).
2. **Tree growing**: 300 decision trees, having at least 5 nodes, are produced using 300 different datasets derived from the training set.
3. **Random forest testing**: the part of the input dataset not used for training is employed for testing the random forest output, predicting the concentration values from the independent variables.
4. **Predictions**: the trained random forest model can be used to predict pollutant concentrations. The model is trained using data in the period 2017-2019, while concentrations are predicted for 2020. In this way, the model predicts a business-as-usual scenario, the concentrations that would have been measured without the restrictions to traffic.
5. **Normalisation**: the normalised time series are produced using the predictions of the random forest model, trained over the entire period 2017-2020. The normalised time series represent the concentrations that would have been measured with average meteorological conditions.

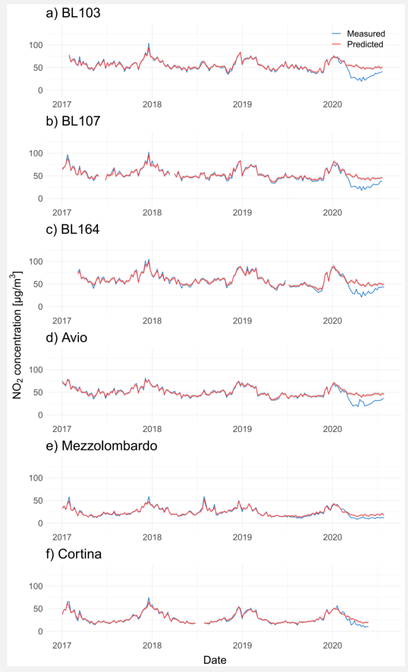
Observed Concentrations

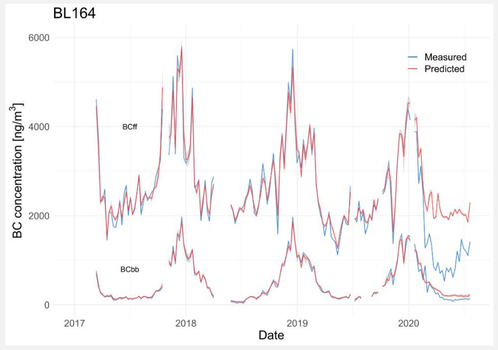


Measured NO_2 and BC concentrations for all the stations analysed.

In the lockdown period a significant decrease of NO_2 concentrations at all the air quality stations was detected, ranging between 38% and 48%. As expected, the traffic stations showed a larger percentage decrease than the rural ones, since they are more affected by the traffic conditions. Considering BC, BC_{bb} slightly decreased during the lockdown with respect to the same periods of the previous three years, while BC_{ff} dropped by 58%. The different behaviour of the two components is due to the different impact of the lockdown measures on their emission sources: BC_{bb} is mainly originated from domestic heating, which was not particularly affected by the restrictions, while BC_{ff} is produced by traffic, which, instead, underwent a heavy decrease during the lockdown period.

Predicted Concentrations

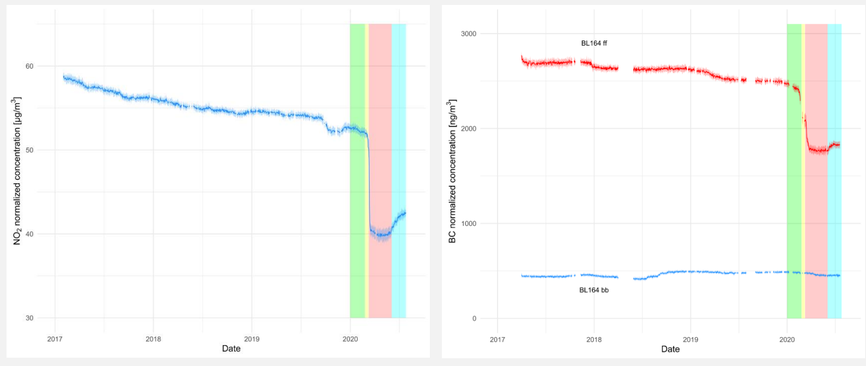




Predicted (red lines) and measured (blue lines) NO_2 and BC concentrations for all the stations analysed.

During the lockdown period the predicted NO_2 concentrations (i.e. business-as-usual scenario) are about 35-45% higher than the measured ones. Considering BC, during the lockdown period the predicted concentrations are always higher than observations for both components. This behaviour is particularly evident for BC_{ff}, which, as expected, behaves similarly to NO_2, since both of these pollutants are mainly originated from traffic.

Normalised Concentrations



Normalised NO_2 and BC concentrations at BL 103 and BL 164.

Being the effects of the meteorological variability on observed concentrations removed, the normalised time series is much smoother than the original one. On 9th March, in connection with the beginning of the lockdown period, an abrupt drop of the normalised concentrations of NO_2 and BC_{ff} can be clearly seen. The effect on BC_{bb} is much less evident.