Factors affecting pollutant concentrations near a highway in an Alpine Valley

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Background

Emissions from traffic represent one of the main sources of air pollutants and may cause serious environmental and health problems, especially for people living close to roadways. These problems may be exacerbated in mountain valleys and basins, where meteorological conditions often lead to reduced atmospheric dilution and, as a consequence, pollutants may accumulate in areas where a large number of persons are potentially exposed to high concentrations.

In this work, in order to evaluate the most important factors affecting nitrogen oxides and particulate matter concentration in the near-road environment, a long term dataset from air quality and meteorological stations at different distance from the A22 highway in the Alpine Adige valley is analyzed. Data come from the network installed in the scope of the European LIFE project "BrennerLEC", aiming at fully characterizing air quality conditions in the Alpine Adige valley and testing policies to reduce pollutant emissions from traffic. Factors taken into account comprise meteorological variables (wind speed, temperature, lapse rate…), traffic (vehicles counts, vehicles types…) and air quality parameters (ozone concentration). Different statistical analyses are performed to evaluate the factors affecting pollutant concentrations close to the highway. Methods include Principal Component Analysis (PCA) and Generalized Additive Models (GAM), which are able to take into account the non-linearity of the variables being compared.

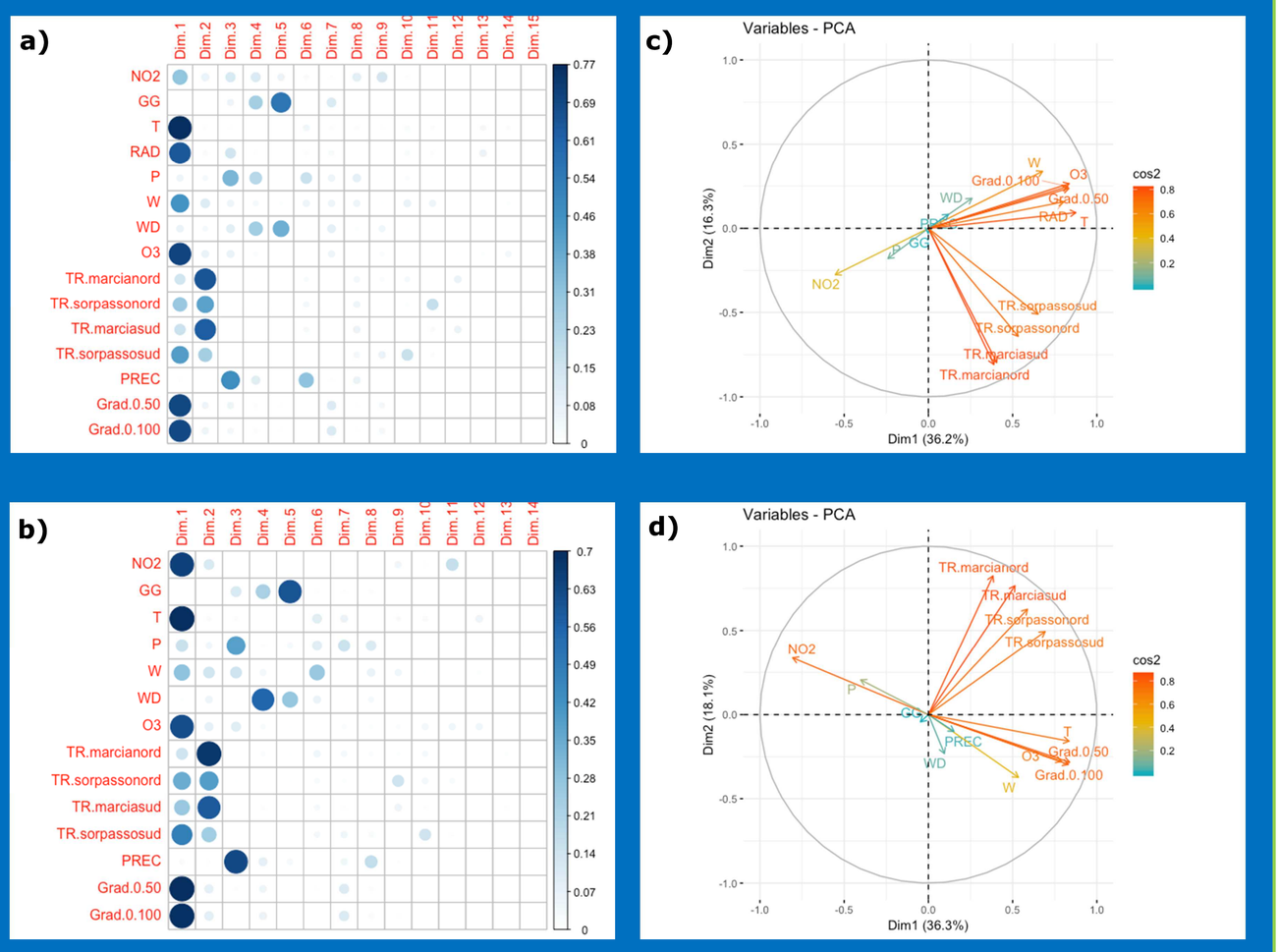
Field Measurements

A dense network of air quality and meteorological sensors is deployed along the Brenner highway.
In particular here data from five air quality stations are analyzed:

- AB1: 5 m from the highway
- ML103: 5 m from the highway
- ML107: 5 m from the highway
- AB2: 30 m from the highway
- CR1: 300 m from the highway

Results: PCA

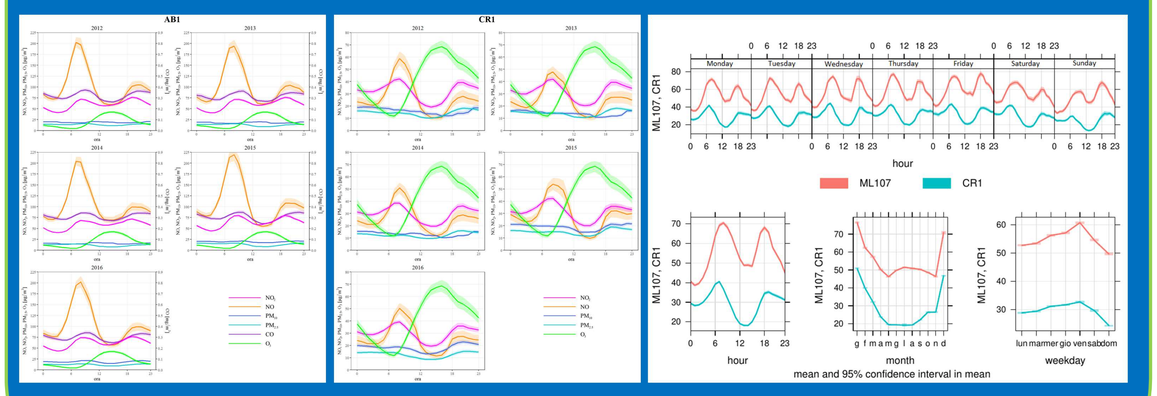
The principal component analysis highlights that, among meteorological parameters, lapse rate, air temperature and wind velocity are generally the most important variables explaining variation of pollutant concentrations. Moreover, ozone is an important parameter for nitrogen oxides concentrations.



Factor maps for NO_2 resulting from PCA at a) ML103 (5 m from the highway) and b) CR1 (300 m from the highway). Correlation circle for NO_2 resulting from PCA at c) ML103 and d) CR1.

Mean Concentrations

Pollutant concentration is strongly dependent on the distance from the highway with different behaviors depending on the pollutant considered. Concentration of nitrogen oxides sharply decrease going away from the highway, while ozone tends to increase. Particulate matter seems not significantly influenced by the highway.



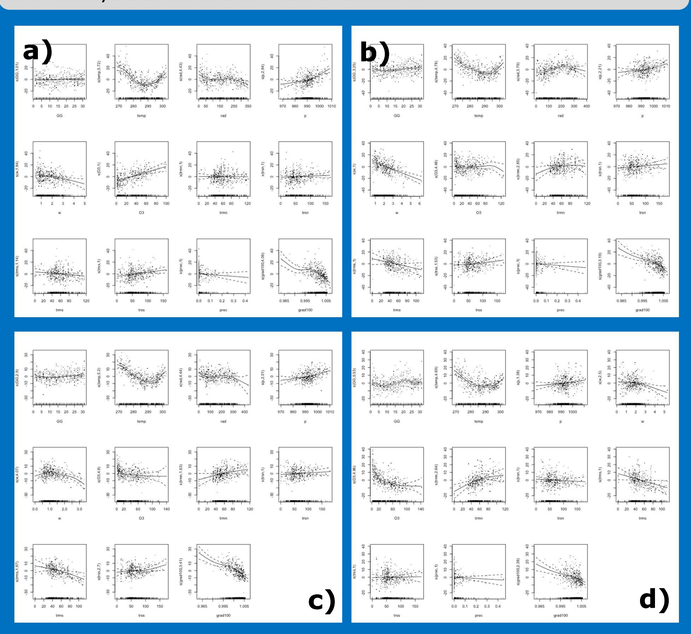
Average diurnal cycles of different pollutants at a) AB1 (5 m from the highway) and b) CR1 (300 m from the highway); c) comparison of NO_2 concentrations at ML107 (5 m from the highway) and CR1.

Results: GAM

The analysis using the Generalized Additive Models for nitrogen oxides highlights that traffic explains a large proportion of variance close to the highway, while its effect decreases far from the highway. On the other hand, ozone exhibits an opposite behavior, displaying the largest explained variance far from the highway, while this factor is less important close to the highway. Among meteorological parameters temperature gradient is the most important factor at all the stations analyzed.

VARIABLES	EXPLAINED VARIANCE			
	ML103	ML107	AB2	CR1
DAY	4.1	1.8	2.3	2.9
TEMPERATURE	20.3	8.0	2.8	5.4
RADIATION	5.5	5.6	4.2	-
PRESSURE	1.1	7.7	10.8	4.8
WIND SPEED	3.4	5.9	1.5	2.8
OZONE	16.2	17.9	50.1	48.5
TRAFFIC	22.9	17.1	10	7.1
PRECIPITATION	0.7	1.1	-	0.8
TEMP. GRADIENT	25.8	34.9	18.3	27.7

Variance explained by different predictors for NO_2 obtained from the GAM analysis at different weather stations.



Dependence between NO_2 concentration and the different predictors at a) ML103 (5 m from the highway), b) ML107 (5 m from the highway), c) AB2 (30 m from the highway) and d) CR1 (300 m from the highway)

ACKNOWLEDGEMENTS

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