Statistical modelling of impact of COVID-19 restrictions to outdoor air quality in Estonia and Latvia

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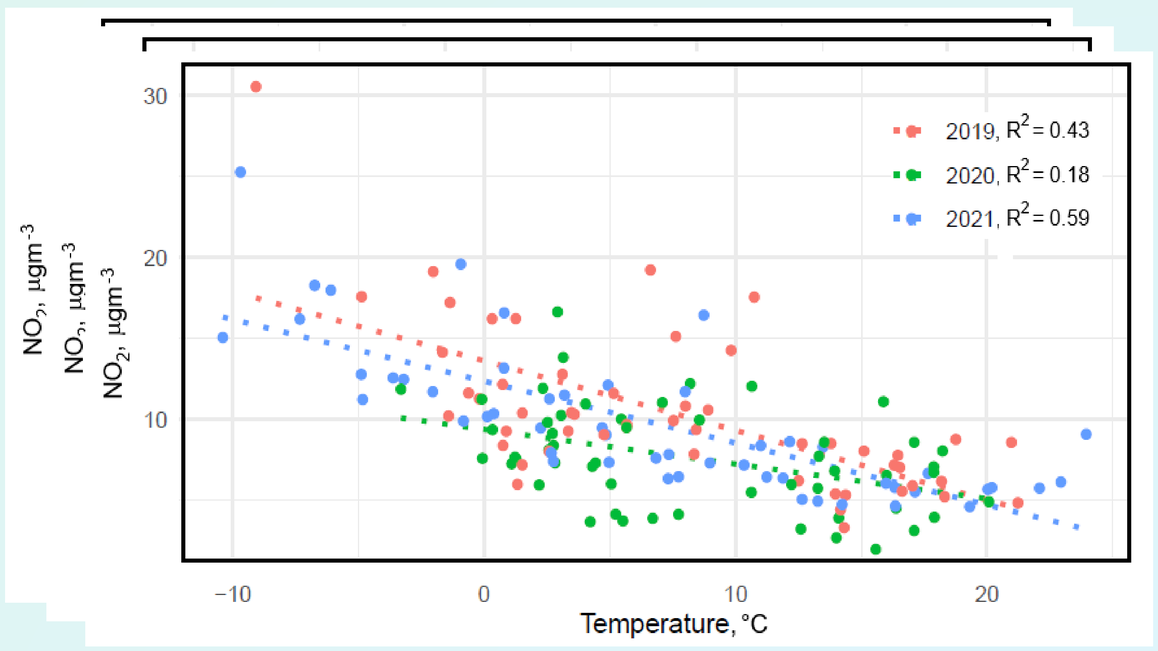

Figure 1. Linear regression of weekly average concentrations of NO_2 in versus ambient temperature (monitoring station: Tartu).

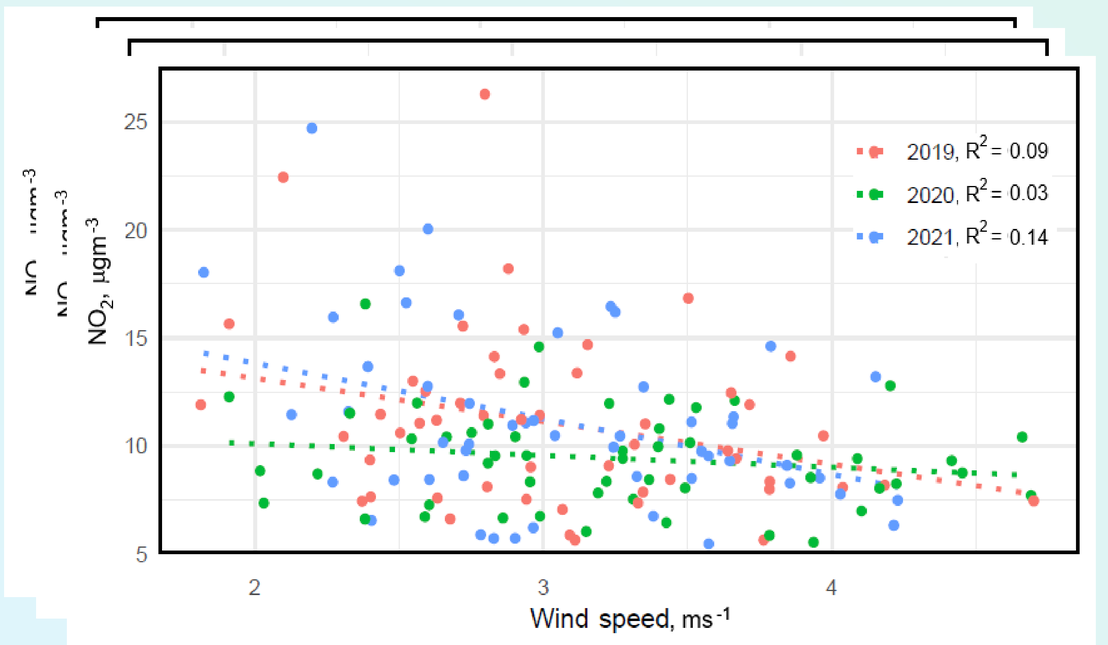

Figure 2. Linear regression of weekly average concentrations of NO_2 versus wind speed (monitoring station: Tallinn-Rahu).

EXAMPLES OF SINGLE VARIABLES AS INPUT TO MULTI-LINEAR REGRESSION

INTRODUCTION

- This is a study focusing on reduction of NO_2 levels in urban air of two Eastern Baltic countries, Estonia and Latvia, during COVID-19 restrictions.
- Cities Under consideration: Riga (Latvia), Tallinn, Tartu, Narva, Kohtla-Järve (Estonia).

METHOD

- Investigating the linear regressions of measured NO_2 concentrations *versus* weather parameters.
- Multi-linear regression of NO_2 concentration against ambient temperature, wind speed and near-surface vertical temperature gradient.
- Comparing the regression residuals in COVID-19 restriction periods (springtime weeks 12 – 18 in 2020 and 2021) with equivalent weeks in 2017 – 2019.
- Expectation: multi-linear regression removes the weather-related emission and dispersion patterns; thus, the impact of source term becomes more evident in regression residuals.

RESULTS

- NO_2 concentration is negatively correlated with ambient temperature due to winter-time stagnating conditions and more intense residential heating (Figure 1).
- NO_2 concentration is negatively correlated with wind speed due to larger dispersing effect of stronger winds (Figure 2).
- NO_2 concentration is positively correlated with vertical temperature gradient due to direct effect of convective *versus* stagnating atmospheric conditions to the dispersion (Figure 3).
- Multi-linear regressions performed for all urban monitoring sites appeared statistically significant (Table 1).
- Average regression residuals in restricted periods *versus* equivalent periods in non-restricted years, except in Riga-Kengarags station, appear lower with statistical significance of 95% (Table 2).
- None of average regression residuals in non-restricted weeks is significantly different of equivalent periods of other years (Table 2).

CONCLUSIONS

- Decrease of urban air pollution due to COVID-19 restrictions, known as mainly a result of reduction of NO_2 emissions from vehicles, is evident in Estonia and Latvia.
- This case can be considered as a „natural experiment“, simulating the future emission reduction after partial introduction of electric vehicles.

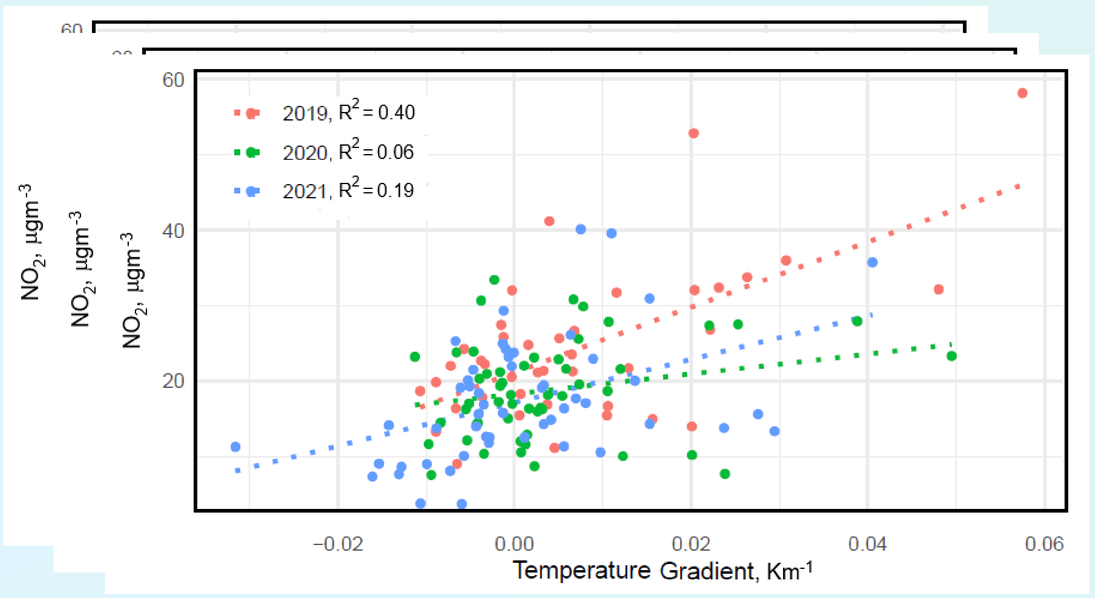

Figure 3. Linear regression of weekly average concentrations of NO_2 versus surface-layer vertical temperature gradient (monitoring station: Riga-Parks).

Table 1. Coefficients of multi-linear regression. The assumed units are: K for temperature, ms-1 for wind speed and Km-1 for vertical temperature gradient. Statistical significance: green at 99.9% confidence level, yellow at 99% confidence level.

Monitoring site	Intercept	Temperature	Wind speed	Temp. gradient
Tartu	20.7	-0.53	-2.44	135.7
Narva	17.9	-0.33	-2.14	60.17
Kohtla-Järve	12.7	-0.22	-1.53	48.91
Tallinn-Rahu	26.6	-0.40	-3.64	85.88
Tallinn-Õismäe	23.1	-0.39	-2.87	111.7
Tallinn-Liivalaia	45.9	-0.54	-6.93	137.0
Riga-Parks	44.4	-0.54	-5.59	176.7
Riga-Kengarags	43.8	-0.96	-4.28	146.9

Table 2. Results of Welch Two Sample t-test: means of multi-linear regression residuals of NO2 (□gm-3) and respective p-values. Statistical significance of difference: green at 99.9% confidence level, yellow at 99% confidence level, red - not statistically significant (p>0.05).

Monitoring site	Restricted weeks in 2020-2021 vs. equivalent weeks in 2017 - 2019		Non-restricted weeks in 2020-2021 vs. equivalent weeks in 2017 - 2019	
	2020-2021	Equivalent	2020-2021	Equivalent
Tartu	-4.28	1.03	0.27	-0.08
Narva	-1.54	0.43	0.10	-0.03
Kohtla-Järve	-1.13	0.68	0.07	-0.06
Tallinn-Rahu	-3.33	0.50	0.21	-0.04
Tallinn-Õismäe	-3.44	0.19	0.22	-0.02
Tallinn-Liivalaia	-5.80	6.03	0.37	-0.49
Riga-Kengarags	-5.21	-2.51	0.35	0.19
Riga-Parks	-6.79	-0.59	0.45	0.04

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