Future air quality of the Brussels Capital Region for the 2050s under the A1B emission scenario

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RMI

INTRODUCTION

Motivation

- Belgium: **air quality levels** of different pollutants (ozone, NOx, Particulate Matter (PM)) still exceed prescribed European norms multiple times a year [1].
- The goal of the European Directives is to keep the number of smog cases per year below predefined thresholds.
- Observed concentrations of air pollutants are sensitive to **climate change**.
- Policy makers express growing interest in quantifying the effect of climate change on air pollution and in the effort required to meet the air quality targets in the next years and decennia [2].

Goal

- Assess the **climate impact** on **air quality** by means of two different **indices** that are based on meteorological conditions determining the dispersion of air pollution.

METHODOLOGY

Transport index

- Characterises a typical **length scale** l (expressed in meter) of horizontal and vertical transport:

$$l = \frac{\overline{u}}{\upsilon}$$ $\overline{u}$: Mean horizontal wind speed; υ: Brunt-Väisäla frequency

$$\upsilon = \sqrt{\frac{g}{\theta}\frac{\partial\theta}{\partial Z}}$$ Measure for the stability of the atmosphere

- Thus: **Low values** for l correspond to low mean horizontal wind speeds, a stable atmosphere and indicate unfavorable conditions for the dispersion of air pollution [4].

Pasquill indices

- Six **stability classes** ranging from very unstable (A) to the most stable atmospheric conditions (F).
- The **classification** depends on the global solar radiation during the day or the cloudiness during the night, combined with the wind speed at 10 m.
- The stability scheme that is used to determine the Pasquill indices has been adopted from [5].

DATA

- Global climate data from **ERA-Interim** and **ARPEGE-Climate** are dynamically dowscaled using the **ALARO-0** model [3].
- Focus on model grid point of **Uccle** (Brussels).

Present DJF 1990/91 - 1998/99		Future DJF A1B Scenario 2046/47 - 2054/55
OBS	Station observations	
ERA	ERA-Interim ALARO-0	
HIS	ARPEGE-Climate ALARO-0	**FUT**

VALIDATION

Transport index

Criterion 1 (C1): l < 100 m, up to a height of at least 100 m for a duration of at least 12 hours.

	Termonia and Quinet (2004) [4]	**This study (ERA)**
Observed extreme pollution peaks of NO_2 concentrations	*3 DJF seasons 2000/01-2002/03*	
5 days	5 days	3 days (see **Fig. 1a**)
Criterion 1 (C1)	*3 DJF seasons 2000/01-2002/03*	*9 DJF seasons 1990/91-1998/99*
	5 days	15 days (see **Fig. 1b**)

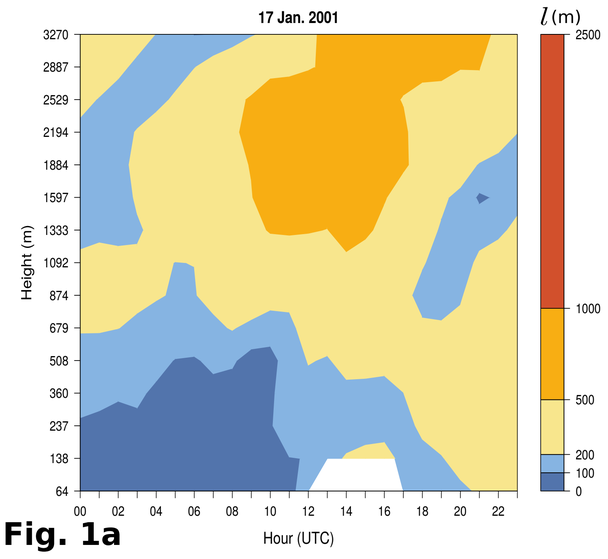

Fig. 1a

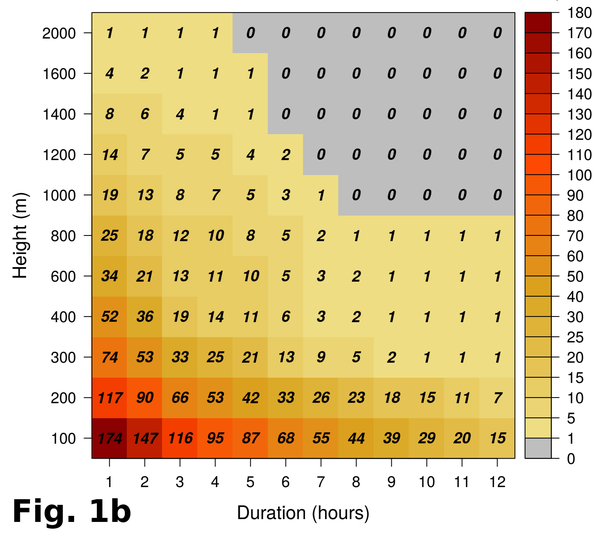

Fig. 1b

Pasquill indices

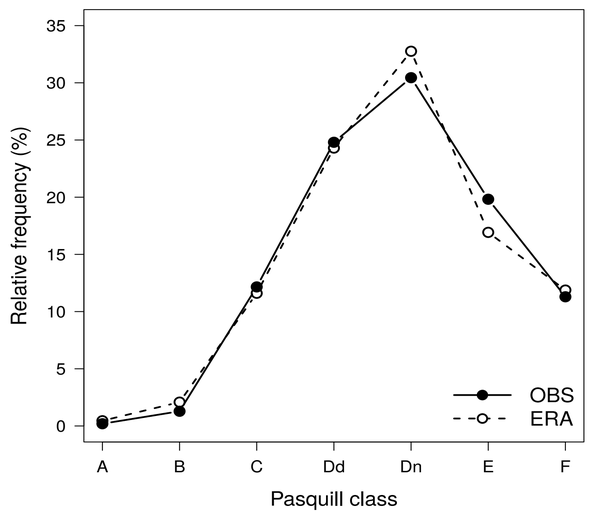

Fig. 2 OBS and ERA show highest frequencies for neutral D_d and D_n indices, followed by the relevant and **stable E and F indices**. ERA coincides fairly well with OBS, with only a slight under- and overestimation for resp. E and F.

IMPACT

Transport index

Biases in driving ARPEGE-Climate → HIS ≠ ERA (**Fig. 3a vs. Fig. 1b**)

Bias correction → On input variables used to calculate l → Alter physcial relationships

Direct correction of l for HIS towards l for ERA → Implies new definition of criterion C1

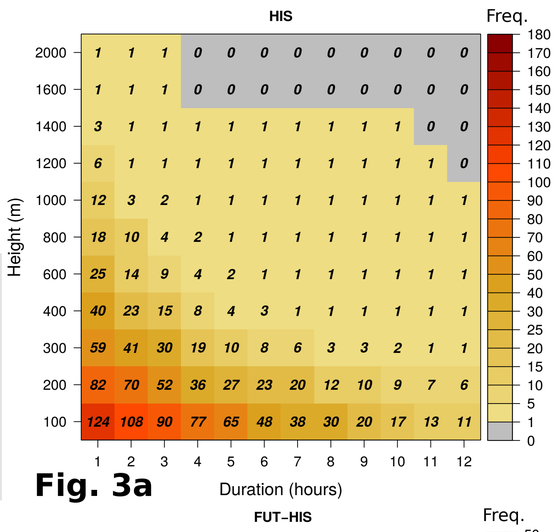

Fig. 3a

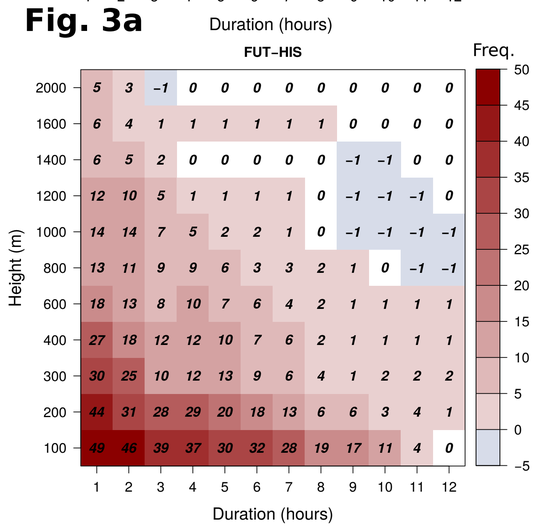

Fig. 3b Consistent positive response in frequencies of transport index values < 100 m for FUT w.r.t. HIS throughout the vertical. Frequencies of l < 100 m are 60 to 80% higher in FUT than in HIS.

Pasquill indices

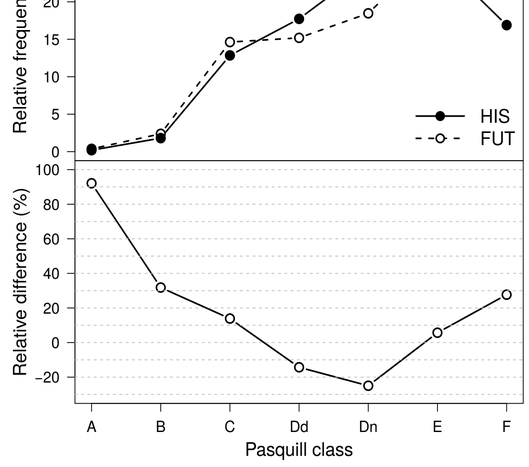

Fig. 4 Shift towards higher relative frequencies of stable Pasquill indices E and F for the future winter period (FUT), supports the positive response .

CONCLUSION

Transport indices obtained with ALARO-0 can be used to detect peaks of extreme concentrations of pollutants such as NO_2.

Based on this analysis we can expect a significant increase of winter smog (60-80%) in Brussels by the middle of the 21st century under the A1B climate scenario.

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[2] Lauwaet, D. et al.: The effect of climate change and emission scenarios on ozone concentrations over Belgium: a high-resolution model study for policy support, Atmos. Chem. Phys., 14, 5893–5904, 2014.
[3] De Troch, R. et al.: Multiscale performance of the ALARO-0 model for simulating extreme summer precipitation climatology in Belgium, J. Climate, 26, 8895–8915, 2013.
[4] Termonia, P. and Quinet, A.: A new transport index for predicting episodes of extreme air pollution, J. Appl. Meteor., 43, 631–640, 2004.
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