Projecting future nitrogen pathways and their impacts: the GLOBIOM-GAINS framework

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Abstract

Global scenario families such as SSP/RCP developed for climate scenarios can be used to assess future environmental impact of reactive nitrogen. Taking advantage of a nitrogen specific scenario framework, the partial equilibrium model GLOBIOM has been coupled to GAINS, a pollution and impact model to provide quantified projections of future reactive nitrogen pollution. Results allow to assess, globally, but in a resolution of individual cities, the impact of nitrogen pollution, specifically on human health. This allows to distinguish the effects of different climate scenarios, and separately informs about efficiency of air pollution measures.

Keywords: Nitrogen scenarios, environmental and health impacts, global developments.

1. Introduction

Based on the RCP/SSP scenario sets developed by the global climate community for use by the IPCC, a framework has recently been established in developing global nitrogen scenarios (Kanter et al., 2019). The GLOBIOM model (Havlík et al 2011, 2014) is able to translate the economic boundary conditions of this framework into input for the GAINS model (Amann et al., 2011), which quantifies potential impacts of air pollution, specifically impacts on human health due to fine particulate matter, triggered in part by nitrogen compounds.

2. Methods

The GLOBIOM model is a global partial equilibrium model integrating the sectors agriculture, bioenergy and forestry. Resulting outputs consist of product quantities for 18 crops, a range of livestock products and forestry commodities, including bioenergy. These results are available at 10 year time steps for 30 regions globally up to the year 2100. It was recently extended to provide sptially and temporally explicit budgets of reactive nitrogen (Chang et al, in prep.).

GAINS uses activity data and projections from external sources. Using a technology database, it suggests cost-optimized emission abatement of air pollutants to achieve environmental targets (such as the premature mortality as a consequence of atmospheric particlate matter pollution) for almost 200 countries and regions globally. Atmospheric dispersion and conversion have been parametrized into a source-recepter matrix (SRM), based on multiple runs of the EMEP global CTM (Simpson et al. 2012). Globally available resolution of the SRM (country-to-grid) is 0.5°, but underlying CTM runs have been provided in 0.1° resolution and partial SRM's at that resolution have been derived for low-level primary PM.

The two models are well suited for integration as they optimize on different elements, production and economic benefit in the case of GLOBIOM, least-cost emission abatement for GAINS. Coupling the two models becomes challenging where the binding conditions used in GLOBIOM (e.g., political framework) touch on technologies that do play a role in GAINS.

3. Results and Discussion

Integrating climate scenarios in future air pollution assessments, specifically focussing on the reactive nitrogen compounds, improves policy relevant conclusions. The method allows to distinguish, for varying climate scenarios and their N impacts, pollution effects as well as possible (remaining) abatement strategies. Fig. 1 shows the case of Shijiazhuang (2015: 12.3 mio. inhabitants), a Chinese air pollution hub, that is strongly affected by nitrogen pollution, demonstrated by the high share of PM attributable to agricultural sources.

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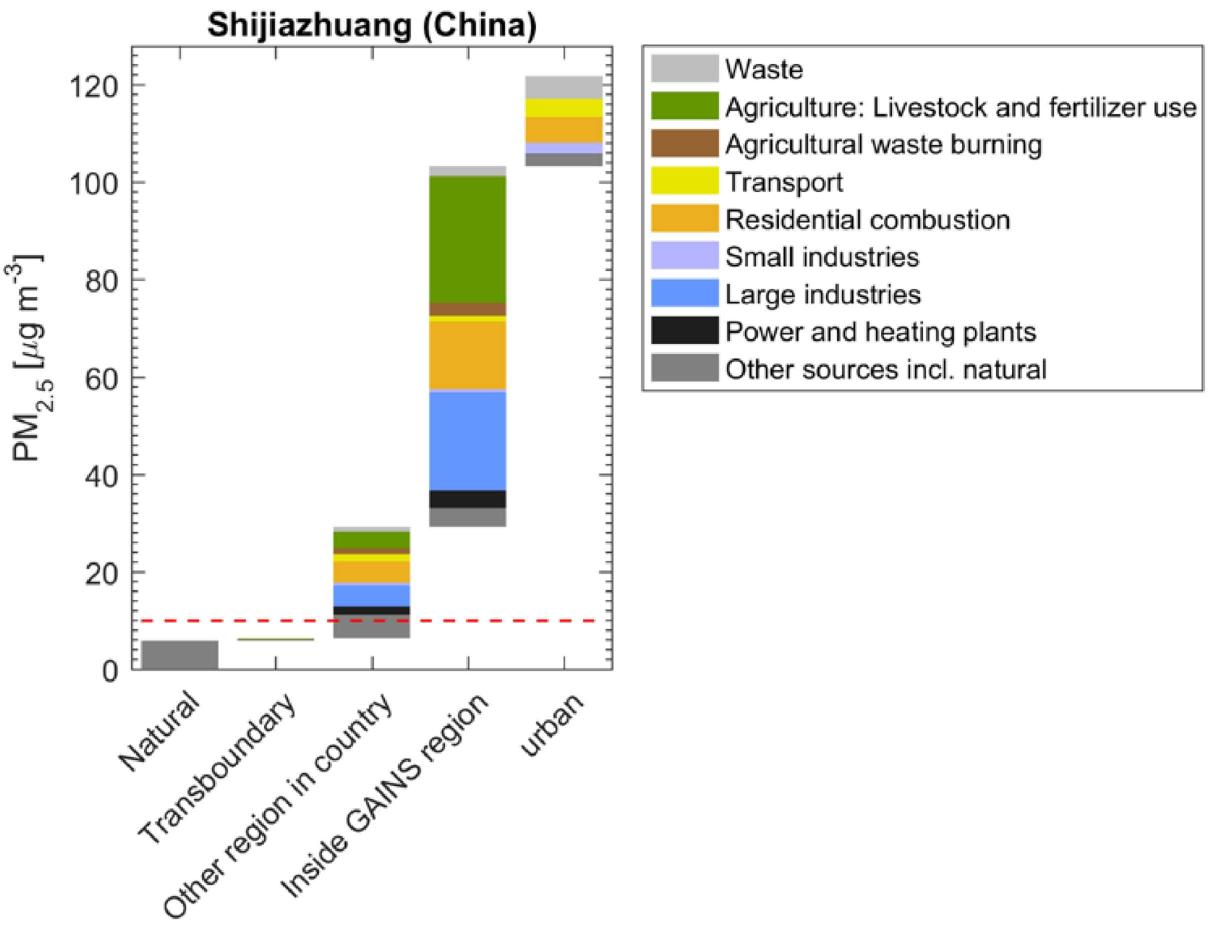

Fig. 1: Source attribution of PM2.5 pollution (annual average) in Shijiazhuang according to GAINS, city center grid cell, for the year 2015. The method allows to isolate source sectors and hence abatement potentials (Kiesewetter et al., unpublished results). The dashed red line is the WHO recommendation.