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Scenarios of global anthropogenic emissions of air pollutants and methane until 2030

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Abstract

We have used a global version of the Regional Air Pollution Information and Simulation (RAINS) model to estimate anthropogenic emissions of the air pollution precursors sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), primary carbonaceous particles of black carbon (BC), organic carbon (OC) and methane (CH_4). We developed two scenarios to constrain the possible range of future emissions. As a baseline, we investigated the future emission levels that would result from the implementation of the already adopted emission control legislation in each country, based on the current national expectations of economic development. Alternatively, we explored the lowest emission levels that could be achieved with the most advanced emission control technologies that are on the market today. This paper describes data sources and our assumptions on activity data, emission factors and the penetration of pollution control measures. We estimate that, with current expectations on future economic development and with the present air quality legislation, global anthropogenic emissions of SO_2 and NO_x would slightly decrease between 2000 and 2030. For carbonaceous particles and CO, reductions between 20% and 35% are computed, while for CH_4 an increase of about 50% is calculated. Full application of currently available emission control technologies, however, could achieve substantially lower emissions levels, with decreases up to 30% for CH_4, 40% for CO and BC, and nearly 80% for SO_2.

Keywords: Air pollution; Climate change; Anthropogenic emissions; Global analysis

1. Introduction

While there are extensive discussions in the scientific literature about the possible future range of global greenhouse gas emissions (e.g., Nakicenovic et al., 2000, IPCC, 2007), we find a comparably modest understanding of how global emissions of the conventional air pollutants are likely to develop in the coming decades. Such information is not only relevant for designing (cost-)effective mitigation strategies that provide acceptable levels of air quality to the population in industrialized and developing countries, but it is also essential input to modelling studies that assess the future chemical composition of the earth's atmosphere (e.g., Dentener et al., 2006, Unger et al., 2006) and their impacts, e.g., on human health (West et al., 2006). Such studies provide increasing evidence about the

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relevance of hemispheric scale transport of air pollutants, through which the evolution of air pollutant emissions at the global scale becomes of direct interest for air quality managers dealing with the regional and local scales (Akimoto, 2003; Dentener et al., 2005).

This paper explores the possible range in which global emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), primary carbonaceous particles of black carbon (BC), organic carbon (OC) and methane (CH_4) could develop by 2030. We generated two scenarios to constrain the possible span of future emissions. As a baseline, we investigate emission levels that would result from the implementation of the already decided emission control legislation in each country, based on the current national expectations of economic development. Alternatively, we estimate the lowest emission levels that could be achieved, for the same assumptions on economic development, with the most advanced emission control technologies that are on the market today.

For this analysis we used a global version of the Regional Air Pollution Information and Simulation (RAINS) model (Amann et al., 2001) and its GAINS extension to greenhouse gases (Höglund-Isaksson and Mechler, 2005). The global model comprises implementations for all countries in Europe (Amann et al., 2006; Kupiainen and Klimont, 2004) and Asia (Cofala et al., 2004; Klimont et al., 2001), which are complemented with country-specific data for North America, Russia and Australia. Latin America, Africa and the Middle East are represented as aggregated world regions only. Thereby, we prepared estimates of the anthropogenic emissions for the period 1990–2030 for 75 countries or country groups.[1] Our analysis does not include emissions from international shipping and from aviation. Emissions from open biomass burning (deforestation, savanna burning, vegetation fires) and natural emissions are also excluded. Other studies estimate global emissions from these sources in 2000 at 3% for aviation, 12% for international shipping and 29% for biomass burning of the NO_x emissions from the sources included in our study (RIVM, 2005). For SO_2, ship emissions account for 8% and biomass burning for 5% on top of the sources covered in our estimates. CO emissions from biomass burning are comparable to the total emissions from all anthropogenic sources. Open biomass burning can be a dominating source of OC, and can exceed releases from anthropogenic sources by factors of 6–7 in Africa and Central and Latin America (Bond et al., 2004).

[1]Detailed emissions by scenario, country and sector are available from http://www.iiasa.ac.at/rains/Glob_emiss/global_emiss.html.

2. Projections of activity levels

For all countries and regions included in this analysis, we collected the available current national perspectives on the sectoral economic and energy development up to the year 2030. For regions where we did not find national projections, we used results from regional modelling studies.

We compiled data on production levels for the main industrial sectors, on fuel consumption by economic sector and fuel type, and different classes of transport activities. We collected projections of livestock numbers, crop farming and waste treatment and disposal.

The national projections of future activities that we have collected for our study reflect expectations of national governments and thereby, in many cases, probably merely policy ambitions rather than the most likely developments. There is no guarantee of international consistency, e.g., between the volumes of exports and imports or in the underlying assumptions on the development of oil prices. Nonetheless, the value of this set of bottom-up projections is that it reflects the expectations on economic development in the coming decades as seen today by countries.

For the Member States of the European Union, for Norway, Switzerland and for Turkey, we have based our analysis on the activity projections that have been employed by the European Commission for the EU Thematic Strategy on Air Pollution (CEC, 2005). For other European countries and for Russia, we used the national projections that have been submitted to the Convention on Long-range Transboundary Air Pollution (Cofala et al., 2006). Activity projections for the United States (US), Canada and Australia have been extracted from national reports (EIA, 2005; NRCan, 2000; DPMC, 2004). For Asia we have taken the national projections collected for the RAINS-Asia implementation (Cofala et al., 2004). For the other world regions we have applied the trends of future economic and energy developments of the IPCC SRES B2 MESSAGE scenario (Riahi and Roehl, 2000; Nakicenovic et al., 2000) to the activity levels