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Human mortality effects of future concentrations of tropospheric ozone

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Abstract

Here we explore the effects of projected future changes in global ozone concentrations on premature human mortality, under three scenarios for 2030. We use daily surface ozone concentrations from a global atmospheric transport and chemistry model, and ozone–mortality relationships from daily time-series studies. The population-weighted annual average 8-h daily maximum ozone is projected to increase, relative to the present, in each of ten world regions under the SRES A2 scenario and the current legislation (CLE) scenario, with the largest growth in tropical regions, while decreases are projected in each region in the maximum feasible reduction (MFR) scenario. Emission reductions in the CLE scenario, relative to A2, are estimated to reduce about 190,000 premature human mortalities globally in 2030, with the most avoided mortalities in Africa. The MFR scenario will avoid about 460,000 premature mortalities relative to A2 in 2030, and 270,000 relative to CLE, with the greatest reductions in South Asia. ***To cite this article: J.J. West et al., C. R. Geoscience 339 (2007).***

Résumé

Effets des futures concentrations d'ozone troposphérique sur la mortalité humaine. Ce travail a pour but de quantifier les effets de trois projections différentes de changements futurs de concentrations d'ozone global sur la mortalité humaine prématurée, à l'horizon 2030. Pour cela, nous utilisons les concentrations journalières d'ozone de surface issues d'un modèle global de chimie–transport atmosphérique et les relations ozone–mortalité tirées d'analyses de séries temporelles journalières. Par rapport aux teneurs actuelles, une augmentation des maximums journaliers d'ozone (calculés à partir des moyennes sur 8 h pondérées par la population) est prévue en 2030 pour les 10 régions du monde étudiées dans le cas des scénarios SRES-A2 et mises en oeuvre des législations actuelles (CLE). L'augmentation la plus grande est prévue dans les régions tropicales. Au contraire, lorsque le scénario « maximum de réductions techniquement possibles » (MFR) est envisagé, des diminutions des maximums journaliers d'ozone sont prévues pour chacune des régions. Selon nos estimations, les réductions d'émissions dans le scénario CLE induisent, en regard du scénario A2, une réduction d'environ 190 000 morts prématurées au niveau mondial en 2030, avec un maximum de morts évitées en Afrique. La mise en œuvre du scénario MFR permettrait d'éviter environ 460 000 morts prématurées en 2030, si on le compare au scénario

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A2 et 270 000 si on le compare au scénario CLE, avec la réduction la plus grande en Asie du Sud. ***Pour citer cet article : J.J. West et al., C. R. Geoscience 339 (2007).***

Keywords: Ozone; Air pollution; Human mortality; Atmospheric modeling; Health effects; Future scenarios; Tropospheric chemistry

Mots clés : Ozone ; Pollution de l'air ; Mortalité humaine ; Modélisation atmosphérique ; Effets sur la santé ; Scénarios futurs ; Chimie troposphérique

1. Introduction

Projecting the concentrations of trace species in the troposphere over the next several decades is important for projecting climate change, as well as for understanding the effects of air pollutants on human health, agricultural productivity, and natural ecosystems. Projecting future emissions of primary particulate matter (PM), and of the precursors of ozone and secondary PM, is likewise important when considering the long-range transport of air pollutants and, for example, the effect of growing emissions in emerging countries on air quality in industrialized nations.

In this study, we address the effects of future ozone concentrations on premature human mortality, in several scenarios for 2030. Ozone is an atmospheric oxidant that has been associated with adverse health effects including hospital admissions and chronic respiratory conditions. In addition, a substantial epidemiological literature documents an association between ozone and premature human mortality through daily time-series studies [1–5,9,12–15,19,22,26].

PM is another major air pollutant that has also been associated with premature mortality, in both daily time series studies and long-term cohort studies [20]. Because PM has been demonstrated to have long-term chronic effects on mortality, while chronic effects have not been demonstrated for ozone, future changes in PM concentrations are likely the most important component of changes in mortalities due to air pollution in future scenarios. While this study focuses on future mortality associated with changes in ozone, an assessment of the total mortality effects of air pollutants would also need to account for changes in PM mortality.

Here we evaluate human mortality globally due to changes in surface ozone concentrations under three scenarios for 2030. We use the results of global atmospheric modeling studies performed by Szopa et al. [24] and Szopa and Hauglustaine [25] to give surface ozone changes. The next section describes these atmospheric modeling simulations and our methods of estimating global human mortality effects associated with these changes in ozone. We then present our estimates of human mortality globally and in ten world regions.

2. Methods

We use results from a global atmospheric modeling exercise performed using a coupled general circulation model with interactive chemistry, the LMDz-INCA chemistry–climate model [8,10,11]. Modeled ozone concentrations for present conditions using this model are shown to agree reasonably well with surface ozone measurements [8,10].

The global simulations used in this study are described fully by Szopa et al. [24] and Szopa and Hauglustaine [25], and these simulations were shown previously to be within the range of several other models in the Photocomp experiment [7,23]. While Szopa et al. [24] and Szopa and Hauglustaine [25] also present results for a regional model imbedded over Europe, and consider climate change scenarios in the future, we consider here only the results of the global model using present-day meteorology (for 2000 from the ECMWF ERA40 reanalysis).

Four scenarios are considered in this study: a simulation for 2000, and projected 2030 emissions under the SRES A2 scenario, the CLE (current legislation) scenario, and the MFR (maximum feasible reduction) scenario. The SRES A2 scenario [17] is a high-growth scenario with rapid increases in emissions of air pollutants. The CLE scenario takes into consideration recently-enacted legislation to improve air quality in nations around the world, and the MFR scenario assumes that currently available emission control technologies are aggressively employed globally [6]. LMDz-INCA is run with a horizontal resolution of 3.75° in longitude and 2.5° in latitude, and mortality effects are calculated on this grid also. Using hourly surface ozone concentrations, we calculate the daily maximum 8-h average ozone concentration on each day and at each grid cell, and use these 8-h maxima to drive the ozone mortality estimates.