Evaluation of effects of stratospheric ozone to policy relevant background ozone

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1. INTRODUCTION

Policy Relevant Background (PRB) ozone was introduced for the purposes of informing decisions about the National Ambient Air Quality Standard (NAAQS) of ozone. It is defined by USEPA as the background ozone level in absence of anthropogenic emissions from continental North American. In other words, it represents the best achievable ozone condition and "how much controllable ozone is available through emission reduction". In ambient environment, ozone is produced from both natural and anthropogenic processes. It is clear that many processes including local emission-induced ozone, long-range transport of air pollution, stratospheric ozone intrusion and photolysis are contributed to the overall tropospheric ozone in North America [He et al., 1999; Price et al., 2004; Wang et al., 2009]. To evaluate PRB ozone in the United States, chemical transport modeling is required for simulating the condition of the where absence of North American (NA) anthropogenic emissions while including all the natural processes and Non-NA emission influences

2. METHODOLOGY

In this study, the GEOS-Chem v8-02-03 global chemical transport model was used to evaluate the potential impacts of stratospheric ozone and long-range transport of air pollution to surface ozone [Zhang et al., 2010]. It is intended to identify the PRB ozone in the United States. A total of six emission scenarios in 2006 were included, and they are Zero-out US, Zero-out Canada, Zero-out Mexico, Zero-out EA, Zero-out NA and Base case. The term "Zero-out" represents anthropogenic emission removal. "EA" represents Asia; "NA" means for North America; and "Base" case stands for normal emission scenarios or control case. Table 1 shows the summary of all emission scenarios used in this study. All GEOS-Chem simulations were conducted with 2^{o}x2.5^{o} horizontal resolution with 3-h temporal resolution on 47 vertical layers using GEOS-5 meteorological input.

Table 1. Summary of emission scenarios

Scenario name	Description	*Removed emissions
Zero-out US	Remove United States emissions	NEI 05
Zero-out Canada	Remove Canada's emissions	CAC & GEIA
Zero-out Mexico	Remove Mexico's emissions	BRAVO
Zero-out EA	Remove Asia's emissions	STREETS
Zero-out NA	Remove North America's emissions	NEI 05, CAC & BRAVO
Base case	Base case with no emissions reduction	-

* NEI05 - National Emissions Inventory at year 2005, CAC - Criteria Air Contaminants inventory, BRAVO - Emissions inventory developed through BRAVO study, and STREETS - Emissions inventory developed by Zhang et al.

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3. RESULTS AND DISCUSSION

3.1 PRB ozone

All the scenarios have been simulated under the Kraken supercomputer at the National Institute for Computational Sciences (NICS) at the University of Tennessee, Knoxville, Tennessee, U.S.A. (hereafter abbreviated as US) and all the outputs have been archived to the high performance data storage unit. Figure 1 shows the PRB ozone in the US from the zero-out NA case for summer. It is clear that the western US has much higher PRB ozone than the eastern US. We suspect that this may due to stratospheric ozone intrusion, where the western US has much higher mean sea level than the eastern US.

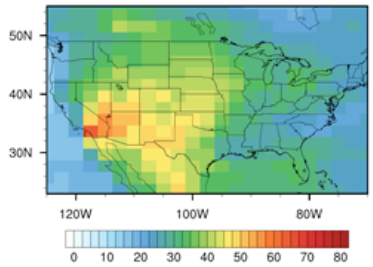

Fig. 1. Summer PRD in the USA

3.2 Impacts of local anthropogenic emissions to overall ozone

Figure 2 shows monthly average ozone differences between zero-out NA case and base case for the month of July. The negative value indicates emission reduction benefit from the zero-out NA case.

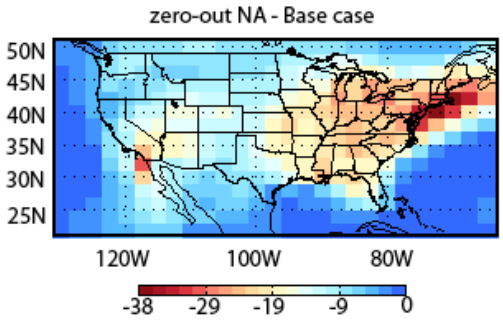

Fig. 2. Monthly ozone differences between zero-out NA and base case

It is noted that the monthly differences are ranged from 0.0 ppbv to –38.0 ppbv in July. The largest differences are observed in North Eastern US. In other words, the maximum monthly achievable ozone reduction is about -38.0 ppbv in North Eastern US. Comparing all six scenarios (not shown), we have found that the largest and least differences are observed in “zero-out NA” and “zero-out Canada”, respectively which indicates that impacts from emission reduction from zero-out Canada is relatively small in summer.

3.3 Impacts of long-range transport on PRB ozone

The “Zero-out EA” case is simulated to understand the effects of long-range transport on PRB ozone. Figure 3 shows monthly average ozone differences between zero-out EA case and base case for the month of July. It shows that the Asian emissions have constituted about 3.0 to 4.0 ppbv of overall PRB ozone.

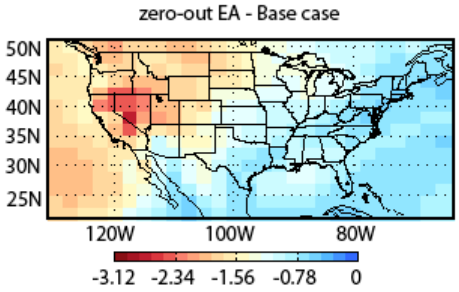

Fig. 3. Monthly ozone differences between zero-out EA and base case

4. SUMMARY

The GEOS-Chem simulations were used to quantify the PRB ozone in the United States. It is clear than the Western US has much higher PRB ozone than the Eastern US due to the stratospheric ozone intrusion. The amount of stratospheric ozone constitutes at least 8 to 10 ppbv of overall PRB in the Western US. The reduction of anthropogenic emissions in the Western US has only a minor impact on overall ozone reduction and the maximum ozone reduction from reducing emissions is only 15.0 ppbv. Conversely, the Eastern US has a relatively small effect from stratospheric intrusion when compared with the Western US. However, reducing anthropogenic emissions has a large impact on overall ozone. It is believed that reducing emissions will be a promising way to reduce ground-level ozone concentration in the

Eastern US. For both Western and Eastern US, the Asian emissions are contributed about 2.0 – 3.0 ppbv of overall PRB.

5. ACKNOWLEDGEMENTS

This research was partially supported by the National Science Foundation through TeraGrid resources provided by National Institute for Computational Sciences (NICS) under grant number [TG-ATM110009].

This research used resources of the Oak Ridge Leadership Computing Facility at the Oak Ridge National Laboratory, which is supported by the Office of Science of the U.S. Department of Energy under Contract No. DE-AC05-00OR22725.

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