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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Interannual variation, decadal trend, and future change in ozone outflow from East Asia" *by* Jia Zhu et al.

Anonymous Referee #1

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Major comments

This study uses a suite of chemical transport model experiments (GEOS-Chem) to examine the extent to which changes in anthropogenic emissions and meteorology influence the outflow of ozone from East Asia under present-day and future climate. The authors show that Asian NOx emissions almost doubled over the historical analysis period 1986-2006, along with increases in VOC emissions and global methane (Fig.1). However, their model with both emissions and meteorology varying over 1986-2006 shows little overall trend in the outflow of ozone from East Asia (Fig.6). This result contradicts with many prior studies suggesting that rising Asian emissions over the past 20-30 years contribute to raising baseline ozone downwind of Asia and over western North America. The referee believes that there are likely some fundamental flaws in the model experiments (or analysis approach). Further in-depth analyses are needed

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to evaluate the modeled ozone response to emission trends.

The referee recommends the following analyses:

(1) Does the model (MetEmis) simulate significant increases in surface and free tropospheric ozone over East Asia during the period 1986-2006? How well do the modeled trends compare with observations? While long-term ozone observations over East Asia are very limited, there are some data available. Please see Section 3 and Figs 4-6 in the following manuscript and references therein:

Lin, M., Horowitz, L. W., Payton, R., Fiore, A. M., and Tonnesen, G.: US surface ozone trends and extremes from 1980–2014: Quantifying the roles of rising Asian emissions, domestic controls, wildfires, and climate, Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-1093, in review, 2016, accessible at http://www.atmos-chem-phys-discuss.net/acp-2016-1093/

(2) This study defines the Asian ozone outflow as the ozone flux through the meridional plain along 135E from 20N-55N and from the surface to 100 hPa. If you restrict the calculation to the surface to 200-300 hPa or up to the tropopause, does the calculated O3 flux change substantially? I wonder if the O3 flux up to 100 hPa is overwhelmingly influenced by stratosphere-to-trposphere exchange (STE) and thus the emission-driven trend is swamped by interannual variability in STE.

(3) This study uses tropospherc column ozone (TCO) retrieved from TOMS/SBUV to evaluate their model simulation of TCO seasonal cycle and long-term trends (Figs 3 and 4). But how good are the TOMS TCO retrivals? TOMS TCO is possibly representative of mid- and upper tropospheric ozone variability. It is not expected to resolve ozone variability in the lower troposphere. So why use TOMS to evaluate the model?

(4) Fig.9 and associated discussions about the future changes.

Changes in atmospheric circulation on regional scales under future climate scenarios are known to have large uncertainty. The different models often yield different results

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and large ensemble members are typically required.

Theodore G. Shepherd, Atmospheric circulation as a source of uncertainty in climate change projections, Nature Geoscience 7, 703–708 (2014), doi:10.1038/ngeo2253.

How many ensembles are included in your experiments? Rather than just showing your results, a through literature review is needed in Section 5 to place your results into context. What is the robust conclusion across the models in the published literature regarding changes in zonal winds and other circulation aspects over Asia under future climate? Do your model agree with the published work?

Other minor comments

Page 2, Line 10: Also cite Jacob et al., 1999 - the first paper on Asian influence on US ozone.

Jacob, D. J., Logan, J. A. Murti, P. P. Effect of rising Asian emissions on surface ozone in the United States. Geophys. Res. Lett. 26, 2175-2178 (1999).

Page 3, Lines 9-10: Also cite Lin et al. (2015b, GRL) - who found that measurement sampling biases substantially influence the ozone trends derived from sparse measurements over the western US originally reported by Cooper et al. (2010, Nature).

Lin, M., .W. Horowitz, O.R. Cooper, D. Tarasick, S. Conley, L.T. Iraci, B. Johnson, T. Leblanc, I. Petropavlovskikh, E.L. Yates (2015): Revisiting the evidence of increasing springtime ozone mixing ratios in the free troposphere over western North America, Geophysical Research Letter, 42, doi:10.1002/2015GL065311

Page 3, Lines 13-15: Also cite Schnell, J. L., M. J. Prather, B. Josse, V. Naik, L. W. Horowitz, G. Zeng, D. T. Shindell, and G. Faluvegi (2016), Effect of climate change on surface ozone over North America, Europe, and East Asia, Geophys. Res. Lett., 43, 3509-3518, doi: 10.1002/2016GL068060.

Page 3, Lines 20-30: Also explicitly discuss the results from Lin et al. (2014, Nature

Geoscience). They found that interannual variability of springtime Asian ozone outflow is strongly influenced by ENSO-related shifts in the subtropical jet stream. Transport of Asian pollution towards the eastern North Pacific during spring has weakened in the 2000s due to more frequent La Nina-like conditions.

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