Review of "Thunderstorms and upper troposphere chemistry during the early stages of 2006 North American Monsoon" by M. C. Barth et al.

General Comments

The authors used the WRF-Chem model with relatively fine grid spacing (4km) to investigate the ozone chemistry during the early stages of the North American monsoon. Since previous studies about convective transport impact on upper tropospheric ozone is mainly estimated based on relatively coarse grid spacing with convection parameterization, the key motivation of this study is to explore the possible substantial uncertainties in those previous studies with coarse spacing. Comparing with meteorological and chemical measurements, WRF-Chem performs reasonable, with biases in simulating convective transport. The ozone budget (chemical production and transport from boundary layer or stratosphere) is analyzed over different geographic regions. The results show that most of ozone chemical production occurs within 24 h of the air being lofted from the boundary layer and ozone mixing ratioes within anticyclone region and outside are similar. Authors also found that ozone in anticyclone is strongly influenced by stratospheric source.

I find this topic about upper troposphere chemistry during the thunderstorms is interesting and important. I would expect this paper's uniqueness in its higher spacing resolution and hence advantages with resolved convective transport and also the budget analysis of ozone. However, this experiment is not well designed. Although, the authors designed some diagnostic parameters to show impact from convection transport, boundary layer, and stratospheric ozone, it's not very clear. I do have some specific comments. I would not suggest this paper for publication in ACP unless the authors address these comments.

Specific Comments

1. The impacts of convective transport, stratosphere ozone, and lightning impact on upper tropospheric ozone are extensively investigated by previous studies, therefore, new insight of this paper is to conduct high spacing resolution simulation. However, authors fail to demonstrate how and to what extent the results from high spacing

resolution that explicitly simulating convective transport differ from those from relative low resolution parameterizing convective transport and also fail to point out the uncertainties in the traditional estimate with parameterized convective transport. A sensitivity simulation with a relatively coarse resolution (e.g., 36 km) should be conducted to quantify the difference of impact of convective transport on upper tropospheric chemistry between explicit one and parameterized one.

2. This paper tries to understand ozone chemistry during the thunderstorms of North American monsoon. Ozone in the free troposphere/upper troposphere is mainly contributed by chemical production, vertical transport from boundary layer and stratosphere, and lightning. These can be estimated by conducting multiple sensitivity simulations [e.g., Choi et al., 2008; Zhao et al., 2010]:
    a. Contribution from transport of boundary layer pollutants can be estimated by subtracting the results of sensitivity simulation without anthropogenic emissions from the results of standard simulation.
    b. Contribution from stratospheric ozone can be estimated by subtracting the results of sensitivity simulation without stratospheric ozone in upper and lateral boundaries from the results of standard simulation.
    c. Contribution from lightning can be estimated by subtracting the results of sensitivity simulation without lightning from the results of standard simulation.
    d. Contribution from convective transport can be estimated by subtracting the results of sensitivity simulation without convective transport from the results of standard simulation. This sensitivity experiment may be difficult for this study since the convective transport is explicitly simulated instead of parameterized. Authors may want to define the convective transport occurs when cloud height or cloud thickness exceed a criteria so that one can artificially turn off convective transport.

    Authors must design these multiple sensitivity experiments to clearly quantify the ozone budget.

Technical Comments

1. Line 5 of page 16412, please include the latitude and longitude range of the two outer domains.
2. Line 22 of page 16412 and line 2 of page 16414 are not consistent. If aerosol affects cloud microphysics, the Lin scheme should be two-moment.
3. Line 17 of page 16414, provide the reference for your dust emissions.
4. Line 20 of page 16414, please provide the reference for lightning NOx production used in the study. The parameterization of lightning NOx production is normally annually dependent (should be scaled by NLDN or other observations for lightning flashes), so please provide the evaluation for the specific period of this study.
5. Line 24 of page 16424, the high bias of ozone above 12 km may be from stratospheric ozone (i.e., upper boundary)? Did you evaluate the upper boundary ozone?

Reference

Choi, Y., Y. Wang, Q. Yang, D. Cunnold, T. Zeng, C. Shim, M. Luo, A. Eldering, E. Bucsela, and J. Gleanson (2008), Spring to summer northward migration of high O3 over the western North Atlantic, Geophys. Res. Lett., 35, L04818, doi:10.1029/2007GL032276.

Zhao, C., Y. Wang, Q. Yang, R. Fu, D. Cunnold, and Y. Choi (2010), Impact of East Asian summer monsoon on air quality over China: The view from space, J. Geophys. Res., 115, D09301, doi:10.1029/2009JD012745.