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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Representing the effects of stratosphere-troposphere exchange on 3D O_3 distributions in chemistry transport models using a potential vorticity based parameterization" *by* Jia Xing et al.

Anonymous Referee #1

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General Comments:

The manuscript introduces a new parameterization for representing vertical, latitudinal, and seasonal variations in upper tropospheric/lower stratosphere (UT/LS) ozone within regional air quality modeling systems. The parameterization is based on regressions between modeled potential vorticity (PV) and observed ozone profiles. Observed ozone is based on measurements from 44 northern hemisphere World Ozone and Ultraviolet Radiation Data Centre (WOUDC) sites. The modeled PV is based on a 21 year (1990-2010) coupled Weather Research and Forecasting (WRF) Community Mul-

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Discussion paper

tiscale Air Quality (CMAQ) model. The new parameterization is able to account for the significant spatial and temporal variation in O3/PV ratios above 100 hPa and thus provides a much more generalized approach then used in previous studies. The impact of the new parameterization is evaluated by comparing a set of 1 year (2006) WRF-CMAQ simulations with WOUDC and surface measurements. Results show that the new parameterization significantly reduces low biases in the UT/LS compared to simulations with a fixed O3/PV ratio of 20 ppb/PVu resulting in positive impacts at the surface in spring. However, the new parameterization increased the high bias in surface ozone during autumn, resulting in negative impacts during this period. The methodology for developing the new parameterization, results, and conclusions are clearly presented and the work is highly relevant to the air quality modeling community. Figures and Tables in the main body of the manuscript are appropriate as are the supplemental figures.

Specific Comments:

The O3/PV parameterization relies on the assumption that both O3 and PV are conserved on planetary and synoptic transport time-scales, which is appropriate at middle and high latitudes of the UT/LS. However, in the tropics, sub-grid-scale convective transport largely determines the vertical distribution of ozone while differential diabatic heating due to convective latent heating/cooling introduces a source of UT/LS PV. As a result, the slope of O3/PV verses pressure shows a great deal of scatter for latitudes less than 30N (Figure S2 in the manuscript). This introduces significant uncertainties in the O3/PV regression in the tropical UT/LS and needs to be acknowledged. As a result, the new parameterization leads to increased Normalized Mean Errors (NME) compared to the reference simulation in the tropical UT/LS (Figure 5f in the manuscript). A discussion of the appropriateness of using the new O3/PV parameterization in the tropics needs to be included in the manuscript. Figure 5 (d) in the manuscript shows that the reference simulation Normalized Mean Bias (NMB) exhibits the classic “C” shaped signature of convective transport and suggests that overestimates in low-level ozone

lead to overestimates in tropical UT/LS ozone mixing ratios in the reference simulation. This should be discussed as well.

Technical Corrections:

Page 1 line 13: The PV based function does not result in assimilation of UT/LS O3 within WRF-CMAQ. I suggest changing “numerically assimilate” to “parameterize”.

Page 1 line 14: Change “parameterized” to “developed”

Page 1 line 20: Change “new function” to “new parameterization”

Page 1 line 22: Change “new function” to “new parameterization”

Page 2 lines 10-26: Suggest adding a statement that co-variances between O3 and other species are not accounted for, which might introduce some inconsistencies in the chemistry

Page 2 line24: Change “numerically assimilate” to “parameterize”

Page 2 line 25: Change “parameterization” to “development”

Page 2 line 33: Add comment on how many vertical levels are above 100hPa

Page 3 line 35: Please comment on the overestimate in the amplitude of the seasonal cycle.

Page 3 lines 36-38: How well does the new parameterization handle LS ozone loss during Arctic springtime?

Page 5 lines 7-12: Please comment on the role of convective transport coupling the UT/LS and lower level overestimates (see specific comments)

Figure 4: Sim-new maps should be the same size as the WOUDC and Sim-ref maps.

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