

## ***Interactive comment on “Dynamic Adjustment of Climatological Ozone Boundary Conditions for Air-Quality Forecasts” by P. A. Makar et al.***

**Anonymous Referee #1**

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General Comments: This article compares ten different approaches for applying lateral boundary and top climatological boundary conditions for ozone using off-line AURAMS. The model performance for each approach was evaluated against North American surface ozone and ozonesonde observations from the BAQS-Met field study period in the summer of 2007. Some approaches reduce (halves) 1-hour surface ozone max bias of the 15ppb in the base case, but at the expense of significant positive biases in ozone concentrations in the free troposphere and upper troposphere. The best overall performance throughout the troposphere was achieved using a methodology that included dynamic tropopause height adjustment, no sponge zone at the model top, extrapolation of ozone when required above the limit of the climatology, and no mass consistency corrections but with the global mass conservation scheme applied. The concept of dynamic, tropopause-referenced adjustments to climatological ozone boundary condi-

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tions introduced here has definitely shown to have a significant improvement on surface ozone prediction accuracy. However, there are a few concerns with the approaches used in the paper.

(1) One of the findings of this paper is that the best overall performance of ozone in the troposphere was achieved using the no mass consistency correction (but with dynamic tropopause adjustment of course) and the best surface ozone performance with the vertical wind correction. To my understanding, AURAMS utilizes the semi-Lagrangian numerical scheme that conserves mixing ratio for pollutant transport, then applies an additional global mass adjustment to improve mass conservation property of the scheme. Therefore, additional mass consistency adjustment schemes introduced (either OPT2, or OPT4) may not be necessary if original AURAMS transport is truly mixing ratio and mass conserving. Note that OPT3 is an incomplete form of mass consistency correction, so its test is of no use. If the redundant correction is applied, now I am worried if the system still can conserve mixing ratio? Has any test performed to ensure if the different approaches utilized has any merit to be included in the set? (2) It is not obvious why the surface ozone positive bias should improve if the corrected vertical wind has tendency to bring down higher ozone from above. I am very concerned to conclude that OPT2 would be the best in improving the surface ozone prediction while incurring significant positive biases in the free troposphere and upper troposphere. Wouldn't it be just due to a compensating error working in the direction of reducing the biases? Isn't the transport process the most important factor here as the PM<sub>2.5</sub> improves most with the OPT4 as shown in Table 3? (3) Usually predicted O<sub>3</sub> shows positive bias in lower concentration range. In such a case, the offset in the regression between the simulated and observed can affect most of the statistical values utilized here. Can we really use these incongruent measures to judge if one approach is better than the others? Bottom line is that considering all the input uncertainties in both meteorology and emissions, the best approach (of mass correction) should be chosen from the theoretical basis a priori with the in-depth understanding of the model configurations. (4) Both GEM (meteorological model) and AURAMS use the scaled

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terrain-following height as the vertical coordinates. Compared to other atmospheric models that use a form of hydrostatic pressure coordinate, a terrain-following vertical coordinate tends to have unwarranted vertical motions in the upper troposphere, which may be responsible for the exaggerated stratosphere-troposphere exchange of pollutants, etc. Also, the correction method OPT2 tends to accumulate divergence errors in the lower atmosphere toward the top of the model. Combination of these two may accentuate the effect of the lateral and top boundary conditions at the downwind of Rockies. Quantification of such mass flux must be made to understand the final effects on ozone simulations.

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