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Interactive comment on "A two-dimensional volatility basis set – Part 3: Prognostic modeling and NO$_x$ dependence" *by* W. K. Chuang and N. M. Donahue

Anonymous Referee #2

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The paper presents further improvement of two dimensional volatility basis set (VBS) approach by including the effects of NOx on secondary organic aerosol (SOA) formation. The formation and evolution of SOA in the atmosphere is a very complex process and 2D VBS provides a novel approach to represent these processes in volatility-oxidation space. In this study the authors added an additional level to the 2D VBS box model to account for organonitrates species and treat their aging under high-NOx conditions. I think the paper is well written and the results are sound. It is well suited for publication in ACP. Also, the authors have provided the code of the updated 2D VBS model in the supplemental for the research community. I have some minor comments

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on the paper. Page 17289, Line 22: I think the VBS approach needs more than 4-7 species to be transported in 3-D air quality models. The number of advected species in 3D models depends on the implementation of the VBS approach, nevertheless at least 10-20 species are needed to be transported for implementation of the VBS approach in air quality models. Equation 7: How much POA do you assume in your calculations? In your calculations OH levels do not change depending on the NOx levels, right? Doesn't this introduce inconsistencies when the model is applied to ambient conditions? The same is true for other species, the 2D VBS model doesn't take into account chemical reactions between gaseous species. One of the ultimate goals of such detailed box modeling studies is to improve the SOA parametrization in air quality and climate models. My main comment is how one can use the findings of this updated 2D VBS box model in air quality models for SOA? I suggest authors to add estimates for sensitivity of SOA yields to NOx levels for major SOA precursors, e.g. toluene, long chain alkanes, terpenes etc. How the branching ratio calculation introduced by Lane et al. (2008) can be improved by using the results of this study? Since the full implementation of the 2D VBS approach in 3D models is not feasible due to the very high number of species that need to tracked, the authors should provide some guidelines how such complex and detailed SOA models could be applied in more simplified SOA parametrizations, which are currently used in a number of air quality and climate models. References: Lane, T. E., N. M. Donahue and S. N. Pandis (2008). "Effect of NOx on secondary organic aerosol concentrations." Environmental Science & Technology 42(16): 6022-6027.

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