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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Simulation of convective moistening of extratropical lower stratosphere using a numerical weather prediction model" *by* Zhipeng Qu et al.

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Review of "Simulation of convective moistening of extratropical lower stratosphere using a numerical weather prediction model" by Z. Qu et al.

This manuscript uses cloud-resolving model simulations with different horizontal resolutions and different treatments of deep convection to investigate the physical processes leading to hydration of the lower stratosphere by overshooting deep convection. The manuscript is generally clear and well written. The results help clarify the roles of advection, wave breaking, and sublimation in hydration of the lower stratosphere. I have a number of minor comments I would like the authors to consider before

publication.

Suggestions for authors

1. It would be helpful if the authors would provide some information about the simulated microphysical properties of the convective tops extending into the stratosphere. Specifically, quantitative information about the simulated ice concentrations and size distributions would be helpful. I realize the simulations use bulk parameterizations, but the two-moment scheme should provide ice concentrations and some measure of the width of the assumed size distribution. Realistic treatment of ice microphysics is important because the simulated convective hydration depends in part on the ice crystal size-dependent sedimentation and sublimation of ice in the lower stratosphere.

2. Page 1, line 30: The authors cite Anderson et al. (2012) here for the influence of water vapor on stratospheric chemistry. I believe earlier references such as *Solomon et al.* (1986) would be more appropriate.

3. Page 2, lines 26–20: I would recommend citing *Smith et al.* (2017) here.

3. Page 3, lines 17–19: It is my understanding that global models generally do not include overshooting convection. If the authors are aware of whether (or how) global models treat overshooting convection, it would be helpful to provide some discussion here.

4. As shown by previous cloud-resolving model studies (e.g. *Dauhut et al.*, 2018) the magnitude of irreversible hydration in the lower stratosphere increases as the maximum heights of overshoots extending into the stratosphere increase. It would be helpful for the authors to discuss this issue within the context of the current simulations. In addition, it would be useful to see how the distribution of overshoot maximum heights depends on the model spatial resolution.

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5. Page 4, line 29: It is confusing (and possibly misleading) to refer to the aircraft flight paths as “trajectories”. It would be better to use terminology such as “flight path” or “aircraft altitude profile”.

6. Page 5, lines 1–10: *Smith et al.* (2017) also did a trajectory analysis to determine the convective systems responsible for the observed lower-stratospheric water vapor plumes. It would be helpful if the authors compared the results/conclusions from the trajectory analysis done here with *Smith et al.* (2017).

7. Figure 4 is presumably a longitude slice through Domain A. An x-axis should be provided. Also, does this slice correspond to a particular latitude, or are the authors averaging over latitude within Domain A?

8. Page 8, line 24: The authors discuss the simulated moisture enhancement in the lower stratosphere. How is this enhancement calculated? Is a difference taken between the post-convection moisture field and the pre-convection field?

9. Page 9, lines 5–10: The authors discuss errors, uncertainties, and biases in the MLS H_2O retrieval. However, my understanding is that the 100-hPa retrievals that are most relevant for this paper are in good agreement with observations.

10. Section 3.4: I believe this section could be better organized. There seems to be a fair amount of repetition, and the discussion seemed to meander. Perhaps this section could be more concise, and a sentence or two at the beginning outlining the analysis techniques would be helpful.

References

Dauhut, T., J.-P. Chaboureau, P. H. Haynes, and T. P. Lane (2018), The mechanisms leading to a stratospheric hydration by overshooting convection, *J. Atmos. Sci.*, *75*, 4383–4398.

Smith, J. B., D. M. Wilmouth, K. M. Bedka, K. P. Bowman, C. R. Homeyer, J. A. Dykema, M. R. Sargent, C. E. Clapp, S. S. Leroy, D. S. Sayres, J. M. Dean-Day, T. P. Bui, and J. G. Anderson (2017), A case study of convectively sourced water vapor observed in the overworld stratosphere over the united states, *J. Geophys. Res.*, *122*, doi:10.1002/2017JD026,831.

Solomon, S., R. R. Garcia, F. S. Rowland, and D. J. Wuebbles (1986), On the depletion of Antarctic ozone, *Nature*, *321*, 755–758.

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