

Interactive comment on “The impact of overshooting deep convection on local transport and mixing in the tropical upper troposphere/lower stratosphere (UTLS)” by W. Frey et al.

Anonymous Referee #1

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This study primarily examines output from a high-resolution, convection-permitting model simulation of Hector convection near Darwin, Australia. In particular, the case study is motivated by aircraft observations of downward transport of ozone-rich stratospheric air. Passive tracers representing both discrete layers and typical background profiles of trace gases allowed for novel investigation of the simulated transport and highlight many important processes at work in the model. In addition, the important work of diagnosing perturbations to water vapor in the UTLS was completed and related to recent literature. Overall, I find the paper to have sufficient detail and be well written and constructed. However, the argument that stratosphere-to-troposphere

C103

transport was observed in the aircraft observations is not convincing and must be addressed in order for the paper to continue to be motivated as such. Though the work required to address my comments listed below is mostly minor in nature, I consider the importance of several issues to be major and required for the paper to be accepted for publication.

Major Comments:

1. Aircraft Observations: I agree that there is evidence of downward transport, but it is necessary to demarcate the bounds of the TTL in Figure 1 as determined by aircraft (and potentially include a profile of temperature and potential temperature for full disclosure). It is stated multiple times in the manuscript that the tropopause altitude for this case is 17.3 km, but the corresponding potential temperature is not clear. Without proper identification of the tropopause the argument that this air has been transported from stratosphere to troposphere is not defensible. For example, the tropical tropopause (cold point) typically varies between potential temperatures of 370 and 390 K. In the profile shown, a tropopause level of 380 K would largely suggest convective stirring of the lower stratosphere, while a tropopause level of 390 K would suggest stratosphere-to-troposphere transport. I should also note that the model simulations suggest the tropopause is at ~ 370 K, which would imply no stratosphere-to-troposphere transport in the aircraft observations.

2. Page 1053, line 14. Though mixing in the cloud should be important, it seems more relevant to me what these conflicting O₃ and CO characteristics say about the sensitivity to vertical tracer gradients. Since the vertical gradient in O₃ from 350–390 K is roughly 3x that of CO, it is likely that the O₃ tracer is more sensitive to changes in vertical velocity. In other words, it would take less time to overcome reductions in O₃ from overshooting than it would for increases in CO.

Minor Comments:

There is a recent paper that documents novel observations of stratosphere-to-

C104

troposphere transport in deep convection that should be cited somewhere in the Introduction: Pan, L. L., et al., 2014: Thunderstorms Enhance Tropospheric Ozone by Wrapping and Shedding Stratospheric Air, *Geophys. Res. Lett.*, 41, 7785-7790, doi:10.1002/2014GL061921.

In addition, there are a handful of modeling studies examining stratosphere-to-troposphere transport that could be cited: Gray, S. L., 2003: A case study of stratosphere to troposphere transport: The role of convective transport and the sensitivity to model resolution, *J. Geophys. Res.*, 108, D18, 4590, doi:10.1029/2002JD003317. Chagnon, J. M. and S. L. Gray, 2007: Stratosphere-troposphere transport in a numerical simulation of midlatitude convection, *J. Geophys. Res.*, 112, D06314, doi:10.1029/2006JD007265. Chagnon, J. M. and S. L. Gray, 2010: A comparison of stratosphere-troposphere transport in convection-permitting and convection-parameterizing simulations of three mesoscale convective systems, *J. Geophys. Res.*, 115, D24318, doi:10.1029/2010JD014421.

Page 1045, line 16: Suggest replacing “intensive” with “intense”

Page 1046, lines 17-20: Please be specific, what are “typical” mixing ratios and how much larger is the elevated feature?

Page 1049, lines 12-13: Please clarify that this is “column-maximum” radar reflectivity here and in the figure caption. Also, how is reflectivity calculated? Are you using the built-in “do_radar_ref” option in WRF? If so, it should be outlined somewhere that equivalent horizontally polarized radar reflectivity for a 10-cm wavelength radar is computed based on that outlined in Morrison et al, 2009, where only Rayleigh scattering is accounted for. Citation: Morrison, H., et al, 2009: Impact of cloud microphysics on the development of trailing stratiform precipitation in a simulated squall line: Comparison of one- and two-moment schemes, *Mon. Weather Rev.*, 137, 991–1007, doi:10.1175/2008MWR2556.1.

Figure 4: The text size in this figure is small and difficult to read. Please increase.

C105

Interactive comment on *Atmos. Chem. Phys. Discuss.*, 15, 1041, 2015.

C106