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Comment on acp-2021-543

Anonymous Referee #2

Referee comment on "On the cross-tropopause transport of water by tropical convective overshoots: a mesoscale modelling study constrained by in situ observations during the TRO-Pico field campaign in Brazil" by Abhinna K. Behera et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-543-RC2>, 2021

Review: On the cross-tropopause transport of water by tropical convective overshoots: a mesoscale modelling study constrained by in situ observations during TRO-Pico field campaign in Brazil (<https://doi.org/10.5194/acp-2021-543>)

Overview: This paper examines perform three simulations of an observational case of stratospheric overshoots using the BRAMS (Brazilian version of RAMS) mesoscale model. The observed cases were from the TRO-Pico field campaign in Brazil. The case studied occurred on 13 March 2012 in Bauru, São Paulo State, Brazil. two lightweight balloon-borne hygrometers intercepted a hydrated stratospheric air parcel originating from two different overshooting plumes. The runs are used to estimate the sensitivity to the model setup, with the intent of studying the physical processes associated with overshoots. They first run a reference case, then run a case with the shape of the hydrometeors changed, and last increase the vertical resolution. However, it appears that the higher vertical resolution case had issues, so they do not include that simulation in the lower stratosphere water budget analysis. However, they show that the model can produce convective plumes somewhat similar to that observed by radar as well as stratospheric water enhancements. They then provide estimates of water flux due to overshooting events. Essentially, they end up comparing 2 cases of the model, and neither case exactly duplicates the observations, but are reasonable. I would recommend some more examination of why the two runs differ, and perhaps consider some other perturbation to the runs to better understand the differences. Some more discussion of the issues with the high vertical resolution run, and how it may be improved are also warranted. I have listed some questions below to be considered in revision. Additionally, the paper needs editing by a native English speaker. It is mostly understandable, but still needs some work. I give two examples here (but did not spend the time doing this for the entire manuscript). i) "Water vapour (WV), a component of the lower stratosphere, is exhibited extensively to be a part of the stratospheric chemistry, and consequently, in the ozone layer balance (Shindell, 1999, 2001; Herman et al., 2002).", this sentence could be rewritten "Water vapour (WV) concentrations in the stratosphere impact both chemistry (Shindell, 1999, 2001; Herman et al., 2002) and the earth's radiative balance." ii) "The tropical belt establishes" should be changes to "The tropical tropopause layer serves as ..."

Questions/Comments to consider in revision:

1) In regards to the nu21 simulation, can you describe what the change in the shape parameter from 2 to 2.1 actually means? The text says: A larger v implies a larger modal diameter with a narrower distribution width. Please give quantitative values at least in regards to model diameter in the text and a sense of the distribution width?

2) Why does the high vertical resolution simulation produce unrealistic results (too much convection)?

3) In Figure 7, the last panel is a water vapor flux. That is not a hydrometeor (as indicated by the caption). Is it just calculated based on vertical velocity and gaseous H₂O? The caption should indicate what is plotted.

4) This figure confuses me; it could be made more understandable with a more detailed figure caption. Is the black line just the sum of the 5 hydrometeors + water vapor? What is ice? Is that just the sum of the 5 hydrometeors? And, what does it mean that the colors show the intensity of the event? Aren't you showing the altitude of the event as opposed to intensity? And, why does the plot start off with no water vapor in the region of interest? The caption (as well as the text) should say that this is a plot with respect to the unperturbed state. And, why doesn't the run go out any further in time? (as that is what is needed to assess how reversible the flux into the stratosphere was.)

5) Conclusion 3 says: "It further indicates that the rest of the 32% ice (principally pristine ice and snow) progresses further up in the stratosphere." Was the model run long enough to verify this?

6) Conclusion 4 says "For this case study, a single overshooting plume injects about 4.15 kt of ice above the 380K level." Where does this value of 4.15 kt come from? Is this an average of the two model simulations? If I then apply Conclusion 3, which seems to say that 32% is irreversibly injected into the stratosphere, then I get close to the 1.34 kt noted as the minimum in the upper limit range noted.

7) In regards to the calculation of the lower limit, is that just making an estimate based on what is water vapor at the end of the simulation? And, another question, why is the ref simulation 2.5 hours, and the nu21 simulation 3.5 hours? Isn't the amount of water vapor at the simulation end going to be a function of how long the simulation actually was?

8) This seems to be results for a specific meteorological event, and not necessarily

extractable to a general case, so I question the final conclusion that this study provides “a road map to upscale the impact of overshooting convection on the stratospheric water vapour at a continental scale.”