

Atmos. Chem. Phys. Discuss., referee comment RC3  
<https://doi.org/10.5194/acp-2021-543-RC3>, 2021  
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## Comment on acp-2021-543

Anonymous Referee #3

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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-RC3>, 2021

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The manuscript describes high-resolution numerical simulations of convection over Brazil during the TRO-Pico balloon campaign. The case studied was chosen because of in situ balloon measurements of stratospheric air which had been moistened by an overshoot from convection in the few hours prior to the measurements. The measurements allow a validation of the simulations. The simulations then allow an assessment of plausible values for the quantity of water injected into the stratosphere by the overshoot from convection. This whole study constitutes a step in a long-term research effort to evaluate the impact of overshoots for the water budget of the lower stratosphere. The style should be improved, and some suggestions are made below. One may regret that there are not more simulations to explore the sensitivity to different parameters, and that out of the three only two are realistic enough to justify the quantitative analysis, but overall the manuscript describes a very interesting case study on a very challenging topic, it is well informed and well documented. I advise minor revisions.

### Major points

1. 165-69: this paragraph is extremely important as it sets the long-term strategy followed by this research group, involving field campaigns and numerical simulations at different resolutions. This is therefore a key paragraph. It would be good to make it a bit more precise and expand a bit. What is considered necessary as 'fine-scale' simulations? In upscaling or generalizing results from fine-scale simulations to a larger scale, with parameterizations in mind, how do the authors suggest to tackle the issue of representativity? What do they expect the key variables from the large-scale state and circulation to be? What are candidates (for the large-scale variables that would, in a parameterization, influence the occurrence or not of overshoots)? CAPE near the surface? The stability near the tropopause? How do these questions influence the design of case studies?

2. 187-93: for readers not very familiar with balloon technology, it would be worthwhile to explain a bit more (what are the different balloons inflated with, which are closed, which are open, what are typical ascent rates, flight durations, maximum altitudes? What are the payloads for different balloons, what are advantages and disadvantages?) and include references for interested readers

3. A major concern is that the authors have only very few simulations to explore the uncertainty on the impacts of overshoots. This is understandable these simulations are costly, and time-consuming to set up, store and analyze. Nonetheless, the simulations that have been made essentially sample the uncertainty due to the model setup. Another set of simulations that would be of interest would be similar simulations (same model setup as the reference simulation for example), but with variations of the large-scale conditions (artificial modifications of, say, lower level humidity, and/or mid-tropospheric humidity, and/or upper tropospheric stability...) to explore the sensitivity of the overshoots to these environmental factors. In the long-term strategy to guide parameterizations, the influence and relative importance of different environmental factors are crucial to estimate, at least qualitatively. It is not reasonable to expect new simulations to be carried out, but such considerations should be explained in a discussion or when sketching perspectives.

4. For the validation, section 4.2, why is the focus so much on the local values? The vertical profiles in different location should be explored? Do simulated vertical profiles, in some places, reproduce the main features of the vertical profiles from balloon measurements?

Minor comments / suggestions:

l5 meteorological model -> climate model (the impact is for climate rather than weather forecasting)

l4-6: the sentence is a bit odd in the sense that it suggests three scales: local scale (cloud-resolving model), intermediate scale (mesoscale modelling?) and the global scale (climate models). What is meant exactly for the intermediate scale is not clear.

l9 numerical simulations depend on ...

l19: '... could establish a forcing scheme...' -> 'could inform the development of / provide guidance for...'

I23: is exhibited extensively to be a part -> is known to play an important role in?

I24: was also an element in the formation of polar stratospheric clouds

I29: 'the supercooled temperature field': there is a confusion here. The temperature field is a well-defined physical field. Supercooled water droplets are a thermodynamic phenomenon concerning water.

I29: 'drives the abundance' -> 'constrains the abundance'? 'determines...'? ?

I32: beyond the level of positive.. -> above the level of zero radiative heating?

I33: known as the cold-trap...

I34-35: It is never certain if such modelling studies 'explain' the abundance of water vapor... perhaps it is better to write: 'These trajectory studies have found agreement with ...'

I35: the text should mention that the studies considered here are just the first studies; the reader is otherwise surprised not to find certain more recent studies, which in fact are commented later in the text

I38: 'conclude' -> show? demonstrate?

I39: 'the processes of WV entering into the stratosphere' -> 'the processes determining the WV entering into...'

I42: 'Recently many case studies'

I52: 'studies report' -> 'studies suggest'? bring evidence..?

I53: 'at a large scale' -> 'on a large scale'?

l63: 'no studies can' -> 'it has not been possible to ..'?

l70: observational -> observed

l72: a range of estimations -> a range of estimates

l72: the remaining 'water'?

l85: 'It' : needs to be explained, too abrupt as it is

l87: equipped with -> based on ?

l92: only the WV measuring instruments were flown: Pico-SDLA...

l107: reference for the ETA model?

l116: 1200g -> 1.2 kg as on line 89, for consistency and for the reader to easily recognize which balloon is referred to

l122-124: relationship between the two measurements?

l128: decayed -> decaying?

l156: determine -> solve

l159: reproduces

l161-162: about the simulations of Liu et al (2010): it reads as if these simulations could

be very similar to the ones carried out here; more precisions would be welcome. Were these simulations validated against observations? How?

l168: before the paragraph explaining the technical setup, the modelling strategy (and in particular the overall choices and compromises for the nesting and domains) should be explained

l171: presentation?

l183: this top is rather low given the height of the phenomena of interest; what is the vertical coordinate? What gives confidence to the authors that this model depth is sufficient?

l187: 'which varies between 2 and 10s for the coarsest / exterior grid' ?

l204: 'all the three' -> the three?

l209: interpreting -> comparing?

l212: 'we determine the cloud top for this range of altitude': ambiguous formulation

l231: is it 'earlier' or 'later'?

l237: remove 'now'

l238: with tops typically at 9 to 10 km altitude?

l243-244: By 15:00 UT, the deep convection altitude in HVR is also higher than in REF...

l249-250: good point, but the formulation is somewhat clumsy; this should be reformulated

l261: higher than REF and NU21: could this be quantified?

l267: inertial gravity wave: should this be internal gravity wave?

l268-269: given that there are only 3 simulations, it is unfortunate to leave one out. Are there not uses that could still be of relevance? (Sensitivity..?)

l366-368 and l372-373: redundant, the second occurrence could be removed

l388-393: very descriptive of model output, but could some more physical interpretation be suggested

l396: no need for a new paragraph

l399-401: this sentence is not very clear; it could read as a criticism of that previous study, yet that study is by the same authors

l501: add 'the simulated': 'the simulated' overshooting plumes reaching...

l513: would it be possible to attempt to translate these numbers into a change of the ppmv content of water vapor, with appropriate assumptions on the volume affected by the injection?

