Review of

Ice injected up to the Tropopause by Deep Convection: 1) in the Austral Convective Tropics

by Dion et al.

General

The study presents a detailed investigation of the diurnal cycle of water vapor and especially ice injected by deep convection into the UT and TL of six tropical regions. The region with the highest amout of UT/TL ice -and thus probably a major source region for stratospheric water- is identified. For that purpose, a clever data evaluation method was developed combining the satellite observations of MLS (lower geographical and time resolution) and TRMM (higher geographical and time resolution). The method was validated (or better say evaluated, see specific comments) using measurements from the SMILES instrument. The topic of the study is of relevance and suitable for publication in ACP. The manuscript is clearly structured and fluently written, the Figures are also clear and mostly self-explanatory.

What I missed in the paper is a more conclusive statement about the importance of the findings and the impact for the research in this area – what new can we learn from this study ? Though the reader can get an idea about this, to my opininion it should be cleary pointed out in the paper at the relevant places (abstract, introduction, conclusions).

A number of specific comments are listed in the following in the order of appearance in the manuscript.

Specific comments

1) line 9 ‘ The impact of deep convection on the water budget ...’

Comment: Isn’t it that in this study the magnitude of water and ice in the UT and TL stemming from deep convection is investigated – to estimate the impact on the water budget you would need to know the magnitude of the other sources of ice, yes ?

2) line 46 ‘.. the region called Maritime Continent (MariCont), the region between the Indian Ocean and the West Pacific …’

Comment: Figure 4 can be introduced already here – then the reader see bettter what region is meant.

3) line 120 2 Datasets Comment: I recommend to rename the section to ‘Instruments’

4) line 127 ‘The MLS IWC sensitivity thresholds do not allow to detect low ice content such as cirrus outflow associated with convective events. MLS IWC sensitivity will mostly be able to detect ice from convective cores. Following Livesey et al. (2017), we will not consider IWC measurements less than 0.02 mg m−3.’

Comment: All the thin cirrus are missed. How does that impact the results ?

5) line Figure 1: Panels a) and c) look identical – is that true or a mistake ?

6) line 173 ‘In DJF, local maxima of Prec, IWC, WV, IWC fraction and RHI in the UT (Fig. 2) ...’

Comment: Prec is shown in Fig. 1, please note.

7) line 185 ff ‘According to the difference between the UT and the TL, WV decreases more with altitude over the MariCont region compared to all other tropical regions.’ ...

Comment: Can you further explain why WV decreases more with altitude over the MariCont ? ‘According to the difference between the UT and the TL’ – what do you mean with that ?

… ‘Consistently, TEMP is lower at 100 hPa (near the CPT) than at 146 hPa and its value is the lowest over the MariCont region.’

Comment: Isn’t it vice versa: consistently with the lower TEMP over the MariCont region the WV is lower ?

8) line 188 ‘While WV decreases by more than 8 ppmv in the TL over the MariCont region compared to the UT, the RHI in the TL reaches high values (RHI ~100 %) highlighting a saturated environment ...’

Comment: This is not a surprise – the high RHI is consistent with the low TEMP. Please note.

9) line 192 ‘To investigate the vertical distribution and the diurnal cycles of water species in the TL, we have defined seven tropical convective zones shown in Figure 4’

Comment: It would be better to introduce Fig. 4 earlier (see comment on line 46).

10) line 211 ‘RHI is lower in the UT than at the TL by ~10 % ‘

Comment: This is not a new finding – please provide references.

11) line 213 ‘The convective lifted ice does not sublimate as rapidly as in the UT ...’

Comment: in case of saturation or supersaturation, the ice does not sublimate at all … as you state later in the paragraph, existing ice crystals even grow and sediment. I recommend to rephrase the sentence to provide a clear picture of the processes.

By the way: dehydratation → dehydration (line 215)

12) line Figure 5 The water vapor axis in panel b), I would recommend to use a logarithmic scale to make the differences in the TL better visible.

13) line 237 ‘Over land, all regions under consideration show a better efficiency to inject ice in the UT during Day than during N. is βx the IWC background.’

Comment: Something is wrong with the end of the sentence (marked in blue).

14) line 259 'Deep convection does not inject directly WV in the UT'.

Comment: Is that true ? Look for example the recently appeared paper:

Convective hydration in the tropical tropopause layer during the StratoClim aircraft campaign: Pathway of an observed hydration patch

Keun-Ok Lee et al.

https://www.atmos-chem-phys-discuss.net/acp-2018-1114/

15) line 327 ' … (the diagram over ocean would look different since maxima appear during local night ton).is defined as the time …

Comment: Something is wrong with the end of the sentence (marked in blue).

16) line Figure 10 What is the dashed red line in panel b) ? **332 '** (see the period of proportionality in Fig. 10).' Is this the dashed red line ? Please indicate.

17) line 333 'This hypothesis considers deep convection represented by Prec as the main process bringing ice into the UT and the TL.'

Comment: Could you please further justify the hypothesis that deep convection is the main process bringing ice into the UT and the TL – what is with the thin cirrus that are not included in your analysis? They can also bring (or form) ice in these regions.

18) line 332, 334 P(t) and Px : P means Prec ?

19) line Figure 11 The colors in the panels are differently defined:

(a) red – IWCp , blue – IWP, black – Prec

(b) red – IWC , blue – PIWP, black – Prec

In the caption (and text) you define pIWP, IWC, Prec. Please clarify.

20) line 356 4.2 Validation of the method with SMILES measurements

Comment:

(a) The SMILES instrument is important for the evaluation of the method, but it is not introduced (for example in Section 2) and no references are given. Please insert a brief description of the IWC detection method and the uncertainties of the measurements to convicingly demonstrate that SMILES is suitable to evaluate the data analysis method applied here.

(b) Validation : I suggest to better use 'Evaluation' , since also the SMILES measurements are no absolute proof.

21) line 393 'NOAA Interpolated Outgoing Longwave Radiation (OLR) during DJF 2009-2010 is consistent with the fact that the convective activity grows higher over land than over ocean (not shown).'

Comment: What do you mean with 'consistent' ? Even if a figure is not presented, the ranges of OLR over land and over ocean should be specified.

22) line 417 how = show

23) line 423 ‘Table 4 presents t_{on}^{TL}, Δt^{TL}, IWC_{min}^{TL} and ΔIWC^{TL} ...’

Comment: t_{on}^{TL} is not shown in Table 4.

24) line 440 ‘… all these results are consistent with the OLR showing strongest values over region having highest OLR signal (not shown).’ ???

25) line 447 ‘… convective processes during the dissipating stage,...’

Comment: As long as convection is active, how can the ice clouds are in a dissipatig stage ? Or do you mean ‘… decreasing convective processes …’ ? See also line **452**.

26) line 483 ‘Other processes may play a minor role such as the decrease of the temperature in the TTL, increasing the saturation ratio and allowing the crystal nucleation and growth, or the bring of ice in the UT and TL by horizontal advection.’

Comment: How do you know that these processes are minor? Do you know their order of magnitude in comparison to deep convection ? From my feeling your conclusion is right, but for an ensured statement I think an estimate of the other processes is needed.

27) line 491 ‘.. the injection of ice over the MariCont-L into the UT and the TL … is the greatest in the tropics.’

Comment: So your finding is that deep convection is the major process feeding the ‘stratospheric fountain’ and not large-scale three-dimensional circulation, yes ? You mentioned in the abstract that the relative importance of the two processes continues to be debated – so I think you could better pronounce the importance of you finding. This is true also for line **495**.

Two papers that might be of interest for you study:

Robrecht et al. (2018): Mechanism of ozone loss under enhanced water vapour conditions in the mid-latitude lower stratosphere in summer, ACPD.

Smith et al. (2017): A Case Study of Convectively Sourced Water Vapor Observed in the Overworld Stratosphere over the United States, JGR.