Author Comment to Referee #2

ACP Discussions doi: 10.5194/acp-2020-552-RC1, (Editor - Gabriele Stiller), ‘Strong variability of the Asian Tropopause Aerosol Layer (ATAL) in August 2016 at the Himalayan foothills’ by Sreeharsha Hanumanthu et al.

We thank Referee #2 for important further guidance on how to revise our manuscript. Our reply to the reviewer comments is listed in detail below. Questions and comments of the referee are shown in italics. Passages from the revised version of the manuscript are shown in blue.

Understanding the nature, origin and impacts of the Asian Tropopause Aerosol Layer has been a research focus for nearly a decade. Recent airborne campaigns conducted in Asia during the Summer Monsoons have provided a wealth of information about the ATAL that are rapidly advancing our understanding of this phenomenon. As a part of the StratoClim field experiment that took place in Nepal and India in 2017, this study present results from the balloon flights conducted from Nainatal in August 2017 compared with those obtained in November 2016. The balloon flights reveal an imporant day-to-day variability of the Scattering Ratio (SR) taken as a relative measure of aerosol loadings. In order to understand the causes of those fluctuations, the authors run the CLAMS trajectory model to distinguish the origin of air masses in the Boundary Layer, the free troposphere and the lower stratosphere from different part of Asia. They concluded that large SR values within the ATAL tend to be associated with air masses from the Tibetan plateau, Himalayan foothills and lands while oceanic origin tend to result in a depletion of UTLS aerosols.

Despite some grammatical mistakes and relatively lengthy manuscript, which could be, shorten and better summarize, this is an interesting study, which merits its publication in ACP. However, I suggest significant revisions to make this possible. Because deep convection is a fundamental transport pathways for air mass to move from the Boundary Layer into the Upper Troposphere and Lower Stratosphere during the Monsoon, the coarse resolution of the meteorological field used to run CLAMS likely result in misrepresentation of the vertical transport pathways *especially after a few days when the likelihood of encountering deep convection is very high. The manuscript lacks a deeper analysis of the role of convective storms that influence the vertical transport of air masses and those measurements. Other studies have used Cloud Top Temperature as a proxy for deep convection to find out the location where air masses are influenced by deep convection and I believe that this study would need to adopt a similar approach to be more convincing. Below are additional technical comments of this paper that the authors may want to consider.*

The reviewer's major comment regarding the representation of convection within CLaMS back-trajectory calculations driven by ERA-Interim reanalysis is discussed in detail under item # 5. We agree that the manuscript is somewhat long therefore we followed the reviewer's advice and removed Fig. 14b, c as well as Fig. 15b (ACPD version) and the corresponding text in Sect. 4.4. Further, the manuscript was carefully proof-read regarding to grammatical mistakes by several of the authors. To avoid any misunderstanding we would like to point out that the paper contains only balloon-borne measurements from India (Nainital) in 2016. Balloon-borne measurements were also performed in Nepal in summer 2017 in the frame of the StratoClim project, however no COBALD measurements are available for 2017.

Minor issues:

1. *Title. Im not sure the title translate very well the topics of this paper. Moreover, the term strong variability is confusing if not related to time information (in this case day-to-day or intraseasonal variability).*

   We agree and changed the title from

   'Strong variability of the Asian Tropopause Aerosol Layer (ATAL) in August 2016 at the Himalayan foothills' to

   Strong day-to-day variability of the Asian Tropopause Aerosol Layer (ATAL) in August 2016 at the Himalayan foothills

2. *P1/L3. I believe that 'inside' is not required. Its understood from the previous part of the sentence.*

We prefer to keep 'inside' to avoid any misunderstanding.

3. *P1/L7. 'COBALD' does not need to be repeated here. It could be replaced by 'compared to those obtained...'*

   We prefer to keep 'COBALD' to have a clear message.

4. *P1/L12-L13. Not 'composition' but scattering ratio.*

   Thanks for the comment. We revised the sentence

   'We identify the transport pathways of air parcels contributing to the ATAL over Nainital in August 2016, as well as the source regions of the air masses contributing to the composition of the ATAL.'

   in the revised version of the paper as follows:

   We identify the transport pathways as well as the source regions of air parcels contributing to the ATAL over Nainital in August 2016.

5. *P1/L18-21. This is related to the major comment I have on this study. How realistic is the vertical transport pathway described here relative to direct injection by deep convection ?*

   Within the Nainital measurements in summer 2016 the ATAL is located from 360 K up to 420 K. The top of the convective outflow level is around 360 K. Deep convection events are most likely underestimated in ERA-Interim. The new high-resolution ECMWFs next-generation reanalysis ERA5 (Hoffmann et al., 2019; Hersbach et al., 2020) has much higher spatial and temporal resolution than ERA-Interim. A recent comparison between CLaMS trajectories driven by ERA-Interim and by ERA5 investigated the impact of tropical cyclones on ozone and water vapour measured during the SWOP balloon-campaign in 2009 and 2015 in Kunming (China) within the Asian monsoon anticyclone (Li et al., 2020). Different vertical transport via deep convection is found depending on the employed reanalysis data

(ERA-Interim, ERA5) and vertical velocities (diabatic, kinematic). Both the kinematic and the diabatic trajectory calculations using ERA5 data show faster and stronger vertical transport than ERA-Interim primarily due to ERA5's better spatial and temporal resolution, likely resolving more convective events. Although the details of the vertical transport are different in all the cases studied by Li et al. (2020), the convective upward transport by tropical cyclones is found in ERA-Interim (diabatic) as well as in ERA5 (diabatic and kinematic). The location of the convective updraft is compared with brightness temperature from IR channel of FY-2D satellite and with cloud top temperature from FY-2G satellite showing that ERA-Interim (diabatic) as well as ERA5 (diabatic, kinematic) trajectories have the convective upward transport in the region of the tropical cyclone, whereby ERA5 (diabatic) fits best with the center of the cyclone. Further, the transport pathway above the convective outflow level driven by both the anticyclonic flow and diabatic heating in the region of the Asian monsoon anticyclone ('upward spiralling range') is found in both reanalysis data (ERA-Interim, ERA5). Li et al. (2020) show that low ozone and low water vapour mixing ratios near the tropopause measured in August 2009 and 2015 in Kunming are the result of the interplay between the uplift of dry ozone-poor maritime air within tropical cyclones and the transport in the UTLS driven by the Asian monsoon anticyclone.

We are aware that using ERA5 for CLaMS trajectory calculations for the ATAL measurements in Nainital 2016 would yield deeper insights into the impact of deep convection to ATAL, however a study using ERA5 goes beyond the scope of the study presented here. Further studies are prerequisite to validate convection and diabatic heating rates in ERA5. In this study, we highlight the day-to-day variability of ATAL during August 2016 and its relation to continental and maritime convection. The use of high-resolution meteorological data and the use of satellite measurements (e.g. Cloud Top Temperature) would be necessary to identify the detailed location of single convection events. However, the results by Li et al. (2020) encourage us that the representation of convection in ERA-Interim is adequate for the study presented here.

6. *P2/L5. Chinese emissions have decreased drastically over the past 2 decades so Sulfur emission in Asia are overall on the decreasing side so this sentence needs to be modified.*

We agree with the reviewer's comment and revised the sentence

'Because of the strong growth of Asian economies, increasing anthropogenic emissions in the future are expected to enhance the thickness and intensity of the ATAL, thereby also enhancing the global stratospheric aerosol loading, which likely impacts surface climate.'

in the revised version of the paper as follows:

On the one hand increasing anthropogenic emissions in the future are expected due to the strong growth of Asian economies, on the other hand implementation of new emission control measures (in particular in China) have reduced substantially the anthropogenic emissions of some pollutants contributing to the ATAL. It needs to be monitored in the future, whether the thickness and intensity of the ATAL will further increase, which likely impacts surface climate.

Further, Chinese emissions are discussed in the Introduction of the ACPD version as well (P3, L25-27).

7. *P2/L9- L11. I would argue that Chinese balloon-borne measurements and ground-based lidar suggested the presence of aerosol layers over the Tibetan Plateau earlier than satellite observations but the extension of the ATAL was indeed discovered through global satellite observations. Refs.:*

   Kim, Y.-S., T. Shibata, Y. Iwasaka, G. Shi, X. Zhou, K. Tamura, and T. Ohashi, 2003: Enhancements of aerosols near the cold tropopause in summer over Tibetan Plateau: Lidar and balloonborne measurements in 1999 at Lhasa, Tibet, China. Lidar Remote Sensing for Industry and Environment Monitoring III, U. N. Singh, T. Itabe, and Z. Liu, Eds., Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings, Vol. 4893), 496503, https://doi.org/10.1117/12.466090.

   Tobo, Y., Y. Iwasaka, G.-Y. Shi, Y.-S. Kim, T. Ohashi, K. Tamura, and D. Zhang, 2007: Balloon- borne observations of high aerosol concentrations near the summertime tropopause over the Tibetan Plateau. Atmos. Res., 84, 233241

We thank the reviewer for these references; we were indeed not aware of these measurements. As suggested the measurements in August 1999 are now mentioned in the paper, when the ATAL is introduced. We added the following text:

Although the large horizontal extent of the ATAL was first seen in the CALIOP measurements (Vernier et al., 2011, 2015), first observations of enhanced number concentrations of sub-micron aerosol particles between 130-70 hPa in the Asian summer monsoon were made during a balloon ascent from Lhasa (29.7°N, 91.1°E) already in August 1999 (Kim et al., 2003; Tobo et al., 2007).

And we are now also referring to the papers in question in the discussion of measurements of size distributions of particles in the ATAL in the introduction further below:

Only few measurements of size distributions of particles in the ATAL are available. Early size-resolved measurements using a balloon-borne optical particle counter (OPC) in August 1999 showed high number concentrations (0.7–0.8 particles cm^{-3}) of aerosol particles with radii of 0.15–0.6 μm between about 130–70 hPa in the Asian summer monsoon (Kim et al., 2003; Tobo et al., 2007).

8. *P2/L17. This sentence needs to be more accurately stated. The paper did not suggest the presence of the ATAL in the 90s but the presence of ammonium nitrate and since we do not know the overall contribution of AN within the ATAL, It's hard to formalize a general statement such as the one here. I suggest being more accurate.*

The paper by Höpfner et al. (2019) contains the following statement: "The spatially resolved AN observations with the CRISTA satellite reveal that enhanced concentrations of AN (0.05-0.3 μg m^3) are located only within the AMA (Fig. 1). These observations between 8 and 16 August 1997 indicate that an ATAL was present in the Asian monsoon UT in summer 1997, years earlier than hitherto thought".

However, we agree that a more careful wording is appropriate here; we have changed the part of the sentence starting with "although" by:

However, Höpfner et al. (2019) reported that as early as 1997, during the Asian monsoon period, enhanced concentrations of solid ammonium nitrate particles were present throughout the Asian monsoon anticyclone.

9. *P2/L26-27. I would suggest targeting the citations that are most appropriate for this statement.*

   Many thanks for this comment. We agree that a plenty of citations are included for this statement. However, in these citations different measurements and chemical species are used. Therefore, we think it is useful to cite all of them here.

10. *P3/L12. I would suggest being quantitative in this sentence. What are the contributions from India and China?*

    We agree and added the percentages from India and China to the revised version of the paper as follows:

    Source apportionment of the model simulations by Fairlie et al. (2020) indicated the dominance of the contribution of regional anthropogenic emissions from China and the Indian subcontinent (both $\sim 30\%$ attributable to regional SO_2 sources) to aerosol concentrations in the ATAL in August 2013.

    In addition, the Chinese SO_2 emissions (Zheng et al., 2018) are also discussed in the Introduction of the ACPD version (P3, L25-27).

11. *P3/L21. Could you explain why the results seem to be consistent with Brunamunti et al., 2018 ?*

    Brunamonti et al. (2018) denote the altitude range between maximum convective outflow and the cold point tropopause as the Asian tropopause transition layer (ATTL). Above, the ATTL, based on H_2O measurements and trajectory calculations, Brunamonti et al. (2018) found a layer of a confined air in the lower stratosphere.

    Vogel et al. (2019) denote the region where air masses are uplifted by diabatic heating across the (lapse rate) tropopause from about 360 K up to 460 K as the ‘upward spiralling range’. The higher the air masses are above the thermal tropopause, the larger the contribution of air masses is from outside the Asian monsoon anticyclone from the stratospheric background coming into the upward spiralling flow.

Both concepts explain the confinement of air in the Asian monsoon anticyclone directly above the cold point tropopause. The higher the air masses are above the thermal tropopause, the weaker is the confinement that can be explained by the larger contribution of air masses from the stratospheric background. This yields a vertical profile of ATAL as shown in Fig. 1 (right; in the ACPD Version of the paper). In Fig. 1 (right), the potential temperature is considered as the vertical coordinate, a top of the ATAL is not clearly defined. Only a slow decrease of averaged BSR_{455} with altitude is observed. This observation is consistent with a decreasing confinement of the air mass within the Asian monsoon anticyclone with increasing potential temperature (Brunamonti et al., 2018; Vogel et al., 2019).

12. *P4/L4. Is there a reference for those estimates?*

Many thanks for this important advice. We revised the paragraph as follows in the revised version of the paper:

Based on CALIOP measurements, the summertime aerosol optical depth over Asia associated with the ATAL has increased from ≈ 0.002 to 0.006 between 1995 and 2013, resulting in a short-term regional forcing at the top of the atmosphere of -0.1 W/m^2 – compensating about one third of the comparable radiative forcing associated with the global increase in CO_2 (Vernier et al., 2015). The regional radiative forcing caused by the ATAL, differs for clear and total sky conditions; total sky calculations show less shortwave radiative forcing over the monsoon region because of cloudiness (Vernier et al., 2015).

It is likely that, over Asia in the past ~ 20 years, the altered radiative forcing has led to summertime reductions in surface temperature, although this effect is not quantified yet. However, the radiative forcing caused by the ATAL could be compared with the global aerosol forcing caused by moderate volcanic eruptions since 2000, which translates into a surface cooling of 0.05 to 0.12 K (Ridley et al., 2014).

13. *Overall, the introduction could be improved by organizing the different*

paragraph with titles.

Caused by the comments of Reviewer #1 and #2 we carefully revised the introducing in several places. Therefore, the introduction in the revised version is somewhat longer than the ACPD version in contrast to the Reviewer's advice to shorten the manuscript. We grouped related topics in different paragraphs without using subtitles.

14. *P5/L9. A reference to Pandit et al., 2015 could be added here . Ref: Pandit, A. K., Gadhavi, H. S., Venkat Ratnam, M., Raghunath, K., Rao, S. V. B., and Jayaraman, A.: Long-term trend analysis and climatology of tropical cirrus clouds using 16 years of lidar data set over Southern India, Atmos. Chem. Phys., 15, 1383313848, https://doi.org/10.5194/acp-15-13833- 2015, 2015.*

    We agree and have added Pandit et al. (2015) at P5/L9 (ACPD Version).

15. *P6/L4. A calibration adjustment is needed to fit the COBALD raw signal to the molecular scattering. A few lines describing a little better the procedure could be added here.*

    Many thanks for this comment. We have replaced the following text in the ACPD version

    'The ATAL analysis is mainly based on the COBALD 455 nm measurements, in particular on the backscatter ratio (BSR), which is defined as the ratio of the COBALD raw signal (from particulates and air molecules) over the pure molecular scattering (derived from the ambient molecular number density, using the temperature and pressure measured by RS41).'

    in the revised version of the paper with:

    The ATAL analysis is mainly based on the COBALD 455 nm measurements. The COBALD data are expressed as backscatter ratio (BSR), i.e., the ratio of the total-to-molecular backscatter coefficient. This is calculated by dividing the total measured signal by its molecular contribution, which is computed from the atmospheric extinction according to Bucholtz (1995), and using air density derived from the RS41 temperature and pressure measurements.

16. *P6L16. If Im not mistaken IST=UTC+5h30...(not 6h).*

    We agree that IST = UTC+5h30. We corrected that in the revised version of the manuscript as follows:

    All balloon soundings with a COBALD instrument were launched at night-time between 23:00 Indian Standard Time (IST) (corresponding to Coordinated Universal Time (UTC) +5:30 h) and next day 03:00 IST.

    and also corrected the figure caption of Fig. 3 (ACPD Version):

    Location of the Asian monsoon anticyclone measured by the geopotential height at 110 hPa for 6 August, 15 August and 18 August 2016 at 18:00 UTC (corresponding to 23:30 local time (IST) in Nainital).

17. *P6.L30. You probably mean to say 'we identify ice clouds with...'*

    We have replaced the following text in the ACPD version including also the comments of Reviewer #1:

    'We reject layers with CI $>$ 7.0, $BSR_{940} \geq 2$ and $S_{ice} > 70\%$ as cirrus clouds (Vernier et al., 2015; Li et al., 2018; Brunamonti et al., 2018)....'

    in the revised version of the paper with:

    We define clear-sky (i.e. cloud-free) conditions; only layers are used in the ATAL analysis where the criteria CI $<$ 7, $BSR_{940} < 2$ and $S_{ice} < 70\%$ are simultaneously fulfilled. All other measurements are rejected from the ATAL analysis. The 70% threshold is on purpose low enough, that it ensures no cirrus cloud measurements are misinterpreted as aerosol measurements (Vernier et al., 2015; Li et al., 2018; Brunamonti et al., 2018).

18. *P9L14. Aerosol scavenging also depends on aerosol size and composition, which affect their ability to uptake water.*

    We have replaced the following text in the ACPD version:

    'This steep gradient represents the top of the convective outflow region (e.g., Gettelman and de Forster, 2002), i.e. below this level more frequent deep convection scavenges the aerosol.'

in the revised version of the paper with:

This steep gradient represents the top of the convective outflow region (e.g., Gettelman and de Forster, 2002), i.e. below this level aerosols are more frequently scavenged and removed by precipitation.

19. *P13L19. How trustable are trajectories run beyond a week ?*

We added the following paragraph to Sect. 2.4 (Trajectory calculations):

In general, trajectory calculations have limitations due to trajectory dispersion depending on the trajectory length. However, the frequently employed trajectory length to study transport processes in the Asian monsoon region is ranging from a couple of weeks to a few months depending on the transport times from Earth's surface to atmospheric altitudes (e.g. Chen et al., 2012; Bergman et al., 2013; Vogel et al., 2014; Garny and Randel, 2016; Müller et al., 2016; Li et al., 2017, 2018). The CLaMS backward calculations to analyse the balloon measurements in Nainital show that the shortest transport times from Earth's boundary layer to ATAL altitudes ($\sim$ 360–420 K, see Tab. 1; ACPD Version) is about 10-15 days (see Sect. 4; ACPD Version). Only a few trajectories are shorter. However, most of the trajectories show longer transport times than two weeks to reach ATAL altitudes (up to $\sim$ 420 K or $\sim$75 hPa). The vertical upward transport of air parcels above the maximum level of convective outflow ($\sim$ 360 K) is determined by diabatic heating rates which are up to $\sim$ 1–1.5 K per day over the region of the Asian monsoon anticyclone during summer based on ERA-Interim (Vogel et al., 2019). Convection occurs on short time scales of hours to a few days, whereby the transport from 360 K up to 420 K needs 40 to 60 days using ERA-Interim. Therefore we performed 40-day backward trajectory calculations here, as well as trajectories with a length of 60 and 80 days to test the sensitivity on the trajectory length.

20. *P14. Table 2 needs to be better explained. What's the definition of the variable in the table? Residence time in a given layer relative to the sum?*

We added in the revised version of the paper the following lines to the caption of Fig. 2:

In the second and third row, the selection criteria for BL, LT, UT, and LS are listed. Trajectories are considered ending in the BL, when they are located for the first time below about 2–3 km (i.e., hybrid coordinate $\zeta \leq 120$ K). The location of this point is referred to as 'end point' of the trajectory in the model boundary layer. For the remaining trajectories ending at atmospheric altitudes ($\zeta > 120$ K), a potential temperature criterion (Θ) is employed to discriminate between origins in LT, UT and LS.

The parameters within Tab. 2 are also explained within Sect. 4 (P13 L29 – P15 L3; ACPD Version).

21. *P30. Figure 15. Why do you choose to take the mean value? I would suggest to plot the same with the value corresponding to the altitude where the model was initialized.*

    It seems that there is a misunderstanding. In Fig. 15 (ACPD version) the mean value of the backscatter intensity ($\overline{\mathrm{BSR}}_{455}$) between bottom and top of ATAL is shown calculated for each balloon sounding using the binned data (see Tab. 1; ACPD version) as explained in Sect. 3.1. Cirrus clouds between top and bottom are excluded in the calculation of $\overline{\mathrm{BSR}}_{455}$. Therefore, $\overline{\mathrm{BSR}}_{455}$ is the backscatter intensity averaged over the ATAL altitude range listed in Tab. 1 for each flight.

    We added the following sentence to the figure caption of Fig. 15 (ACPD version) to the revised version of the paper

    $\overline{\mathrm{BSR}}_{455}$ is the backscatter intensity averaged over the ATAL altitude range listed in Tab. 1 for each flight (details see Sect. 3.1; ACPD version).

22. *Figure 15. What are the correlation coefficient values? Im not sure if you can draw much conclusions from this plot apart overall tendency.*

    Many thanks for this comment. We added a new table (Tab. 1 within this authors' reply; Tab. 5 in the revised version) showing the correlation coefficients for each region and added the following paragraph to the revised version of the manuscript:

    Further, the Pearson correlation coefficients between the different regions (Tibet, Foothills, Land and Ocean) and the backscatter intensity averaged over the ATAL altitude range (($\overline{\mathrm{BSR}}_{455}$-1) $\times$ 100) for the location of the end points of the trajectories and for the location of the strongest updraft along the trajectories is calculated (see Tab. 1; in this author comment). Low positive correlations (i.e. values from 0.3 to 0.5) are found for the location of the end points of Tibet and Foothills as well as for the location of the strongest updraft of Tibet.

Moreover, the Pearson correlation coefficients are calculated excluding also the flights with a relatively low absolute number of trajectories (11, 21, 23 and 26 August) and the no ATAL case on 15 August. The no ATAL case is excluded because the low backscatter intensity is not completely explained through the backward trajectory analysis presented here. Moderate positive correlations (i.e. values from 0.5 to 0.7) are found for Tibet, Foothills and Land with the largest correlation coefficient of 0.7 for the location of endpoints in Tibet. Low negative correlations (i.e. values from -0.3 to -0.5) are found for contributions from the Ocean. Overall, our findings show that the stronger the backscatter intensity averaged over the ATAL altitude range, the higher the continental contributions from Tibet, Foothills and Land. The weaker the ATAL is during August 2016, the higher are the maritime contributions.

23. *P31/L17. This phrase needs to be nuanced. While it is true that the signal-to-noise ratio from the CALIPSO space-borne lidar does not allow studying day-to-day variability of the ATAL, observations from SAGE II/SAGEIII can be potentially used for that.*

    Following the reviewer's advice we revised the sentence

    'This variability is not visible in the climatological mean values of the ATAL derived by satellite observations.'

    in the revised version as follows:

    In contrast to high-resolution in situ measurements, space-borne observations often do not allow studying the day-to-day variability of ATAL profiles therefore mean values of ATAL profiles were frequently used in previous studies based on satellite observations. (e.g. Vernier et al., 2011, 2015).

24. *P31/L24. I don't think the impact of convection, which is not well represented in ERA-Interim, has been fully explored and thus must bias most of*

Pearson Correlation Coefficients				
location of	Tibet	Foothills	Land	Ocean
end points	0.33	0.35	0.14	-0.19
strongest updraft	0.41	0.09	-0.00	-0.19
end points*	0.70	0.63	0.56	-0.27
strongest updraft*	0.69	0.52	0.58	-0.32

Table 1: Pearson correlation coefficients between the different regions (Tibet, Foothills, Land and Ocean) and the backscatter intensity averaged over the ATAL altitude range (($\overline{\mathrm{BSR}}_{455}$-1) $\times$ 100) for the location of the end points of the trajectories (see Fig. 15; revised version) and for the location of the strongest updraft. For each region the Pearson correlation coefficient was calculated using all measurements except the one on 12 August, when the UTLS is filled by a 5 km thick cirrus cloud. Further, the Pearson correlation coefficients are also calculated excluding in addition low statistics flights (11, 21, 23 and 26 August) where the trajectory number is lower than 50% of the maximum number of trajectories (#704) calculated on 18 August 2016 (see Fig. 14a; revised version) as well as the no ATAL case on 15 August (marked by *).

the trajectory results presented in this paper.

Thank you for this comment. We added in the revised version of the paper, the following sentence to the conclusions

Clearly the details of the vertical transport will differ, when a higher resolution, more recent reanalysis data set would be used, however the general transport patterns will likely remain unaltered. For example, the convective upward transport by tropical cyclones is found consistently for ERA-Interim and ERA5 in diabatic calculations (Li et al., 2020).

and the following statement to Sect. 2.4 (Trajectory calculations):

In ERA-Interim changes are implemented to improve deep and mid-level convection compared to previous reanalysis data (Dee et al., 2011). However, small-scale rapid uplift in convective cores is not included. Therefore convection over Asia is most likely underestimated in ERA-Interim. Nevertheless, upward transport in larger convective systems such as tropical cyclones is well represented in CLaMS trajectory calculations driven by

ERA-Interim as shown in Li et al. (2017, 2020) by comparison with brightness and cloud top temperature derived from satellite observations.

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