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Discussions

Interactive comment on "16 year climatology of cirrus clouds over a tropical station in southern India using ground and space-based lidar observations" *by* A. K. Pandit et al.

Anonymous Referee #1

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Review of:

16 year climatology of cirrus clouds over a tropical station in southern India using ground and space-based lidar observations by A.K. Pandit et al.

1   General comment:

The paper describes a rather detailed study for long therm lidar observations (16 years) of cirrus clouds at a tropical site in India. Different cirrus cloud properties are con-

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sidered and discussed. Especially, the trend analysis is one important key point of the study. The local lidar measurements are compared with satellite measurements of CALIPSO and a rather good agreement between both measurements methods is found. The manuscript is well organized and the analysis and results are clearly communicated and contextualized. In general, this is an appropriate and scientifically relevant contribution to ACP. I recommend minor revisions, i.e. some issues should be clarified before the manuscript can be accepted for publication. In addition, i recommend language revisions. I tried to find some of the issues (listed in the technical comments), but due to the great number, i could not list all of them.

2   Specific comments/questions:

p. 15795: In the description of the NARL lidar the orthogonal aligned PMT are mentioned. This sounds like the NARL lidar is able to measure the depolarization of particles. If so, why not using the depolarization data as indicator for ice clouds ?

p. 15798 Section 3.1: In this Section the cloud detection algorithm is described briefly. You state that the algorithm is optimized to detect very thin clouds. Can you please provide some numbers, what is the smallest/ thinest cloud with respect to vertical and spatial extent you could detect with the algorithm. This numbers should also stated for CALIPSO, as they are quite important for comparing numbers/frequencies of thin clouds. Are you applying any additional profile smoothing in time or vertical ? How sensitive is the detection algorithm with respect to noise in the backscatter profiles ?

p. 15798 ll 8: You considered only those clouds with a base temperature of below -20°C. Would it be better to use a temperature of -38°C (235 K) for classification of cirrus layer, since below this temperature liquid cloud droplets no longer form. The temperature range between -38°C - 0°C is assigned to mixed phase clouds where the coexistence of water droplets and ice particles typically occur. The ice water content

as well as the optical depth in such even though completely frozen clouds is much higher compared to real cirrus clouds found in temperatures below -38°C. How would your results change, if you take only those clouds below -38°C which are then most certainly cirrus clouds?

p. 15799 ll 22-25: As you wrote before, multiple scattering is important to consider. Why do you use different multiple scattering correction factors (0.75 and 0.6) for the NARL and CALIPSO extinction retrieval ? The correction factor depends strongly on the Field of View (FOV) of the lidar receiver. Does NARL have a similar FOV as Sassen Cho (1992) used in their study or why did you chose the same correction factor ?

p. 15801 ll 14-15: You mentioned the quite large difference between CALIOP and NARL PO distribution and explained it with occurrence of cloudy nights during the monsoon season. However, Figure 2d shows no significant difference between CALIPSO and NARL PO distribution during the monsoon season in order that this may not be the right reason for the difference. Except for the post-monsoon season all PO distributions from the NARL lidar appear to be comparable with CALIOP. For combining Figures 2b-e into the Figure 2a it seems that the most of the data are collected during Post-monsoon season. That brings me to the question of how many profiles are used for each season for CALIOP and NARL? Another reason for the difference could be attributed to different bin-width in determining the PO distribution for the CALIOP and the NARL lidar. Are you using the same bin-width for the NARL and CALIOP PO distribution ?

p. 15803 ll 10-16: The day night time difference in PO depends strongly on the amount of CALIOP profiles. How significant are these differences, especially the slightly larger day-time PO during September and November ?? Can state some explanation, why the day-time PO could be larger compared to the night-time PO?

p. 15804 ll 20-21: "Quite a good number", can you please state a percentage number for NARL and also for CALIPSO. Did you checked the differences in the FNL and

GMAO tropopause heights as well as the temperature data ?

p. 15804 ll 24-25: Is there an explanation for the noticeable peak at 75°C in the NARL mid-cloud temperature ?

p. 15804 ll 26-28: Can please state the percentage of sub-visible, thin and thick cirrus clouds also in the respective panel of Figure 6 (b-d) as text. Than it is easier to understand the composition of panel a.

p. 15807 ll 19-22: Is there an explanation why CALIPSO underestimates the thickness in day-time profiles ?

p. 15808 ll 9-13: This point is very unclear and needs further explanation: The difference in geometrical thickness between Sunilkumar and Parameswaran (2005) and your study can be hardly explained by different temperature data. The geometrical thickness measurement itself does not depend on temperature due to the good resolution of a lidar. Only the individual cloud thickness could be shifted to other temperature bins, but this would require a temperature difference between both datasets of more than 20K to explain the big difference of temperature / geometrical thickness distribution.

p. 15808 ll 15-17: The dependence could be weaker, but as you wrote before (p. 15807 ll 19-22) the cloud thickness in CALIPSO day-time profiles could also be underestimated. I think this needs a bit more discussion what is the reason for the day/night time difference.

p. 15810 l 2: Can you please state the trend of decreasing optical thickness of thick cirrus clouds in the text. Maybe it is also helpful, to show this significant trend also in a Figure.

p. 15810 l 12-15: This statement needs clarification, because the intention is not clear and the arguments are contradictory. First you wrote that there is a warming trend at 100 hPa. In the next sentence you wrote the warming decreases rapidly and becomes

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cooling ???

p. 15811 l 3-5: Can you please state a percentage number also in the conclusion section. Because it is an important point for water vapor entry into the TTL.

p. 15811 l 8-11: As i mentioned before, i did not understand the difference in the Temperature/Thickness distribution and the corresponding explanation.

3 Technical comments:

p. 15792 l 6: missing "a": "seven and a half"

p. 15792 l 9: missing "the": "and the differences"

p. 15793 l 18: missing "a": " in a General Circulation Model (GCM) grid box."

p. 15793 l 20: missing "a": " results in a substantial..."

p. 15794 l 20: missing "a": "seven and a half"

p. 15794 l 21: Change "onboard" to "aboard".

p. 15794 l 27 and 28: Change "resolutions" –> "resolution"

p. 15795 l 1: Change to "as they are being viewed from the top."

p. 15795 l 11: Remove "the": "...cirrus clouds using both lidars."

p. 15795 l 15: missing "the": "... at the National Atmospheric Research Laboratory (NARL)..."

p. 15795 l 16: missing "of a": "... this is the longest duration of a ground-based lidar..."

p. 15795 l 19: missing "the": "A brief description of the NARL lidar..."

p. 15795 l 20: missing "the": "The NARL lidar..."

p. 15795 l 22: two missing "a": "...each pulse has a pulse energy... and a pulse duration of..."

p. 15796 l 7: missing "the": "...integral part of the afternoon-train..."

p. 15796 l 14: Change "onboard" to "aboard"

p. 15796 l 17: missing "an": "...having an averaged pulse energy..."

p. 15797 l 8: change "which" –> "them"

p. 15797 l 14: missing word "amount": "... a total amount of ..."

p. 15797 l 14: I suggest to state the number of profiles which were used in the climatology instead of reporting the numbers which cannot be used due to cloudiness. It think this should be then 1104 (1146) profiles used for the comparison.

p. 15797 l25: change "was" –> "were"

p. 15798 l 7: missing "a": "...we used a temperature..."

p. 15798 l 16: change "frequently" to "frequent"

p. 15798 l 19: missing "the": "by taking the ratio "

p. 15799 l 7: missing "the": "...provided by the Global..."

p. 15800 l 6: missing "the": "...CALIOP, the fully..."

p. 15800 l 16: missing "are": "...and are located below..."

p. 15800 l 21: missing "the": "For comparison with the NARL lidar,..."

p. 15800 l 23: remove "the": "For both nights, the ..."

p. 15800 l 24: missing "a": "... show a very good agreement..."

p. 15801 ll 3-7: Here, you wrote that both observations with NARL and CALIOP on 20 November 2008 are comparable with same optical optical properties (i.e. extinction).

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In contradiction, you wrote on page 15800 ll 24-26 that the structure and the magnitude in extinction is not the same. Can you please correct the inconsistency.

p. 15801 l 5: missing "the": "On the contrary, the cirrus layer"

p. 15801 l 5: remove "the": "... using both lidars..."

p. 15801 l 6: change to "exhibits"

p. 15801 l 6: change "their" to "the"

p. 15801 l 7: remove "observed by the two lidars."

p. 15802 ll24-25: Please put the references in chronological order.

p. 15803 l 1 and 5 and ofter later on in the text. Please remove "the": "... from both lidars..."

p. 15803 l 23: missing two "the": "During the monsoon season..., the number of lidar..."

p. 15803 l 28: missing "a" and "the": "Overall, we see a very good consistency between the two lidar systems"

p. 15804 l 5: change to: "and the thermodynamical property"

p. 15804 l 5: missing "and": "distance from tropopause, and geometrical thickness"

p. 15804 l 8: missing "a": "...lidars show a good agreement..."

p. 15804 l 13: Please change to "...show a nearly one to one correspondence...". Because it agreement ist not perfect!

p. 15805 l 5: missing "the": "...base altitude of the cloud..."

p. 15805 l 11: change "more" to : "...have a larger number of..."

p. 15805 l 11: missing "the": "...thin clouds in the altitude ..."

p. 15806 l 5: rephrase "It is worth to mention that the aircraft studies ..."

p. 15806 l 7: rephrase "...sub-visible cirrus cloud with thicknesses less ..."

p. 15807 l 1: missing "the": "...function of the mid-cloud altitude ..."

p. 15807 l 6: missing "a" and "the": "...lidar has a peak in the frequency ..."

p. 15807 l 15: missing "the": "In case of the NARL lidar ..."

p. 15807 l 16: missing "the": "..., whereas in case of CALIOP the peak of the frequency ..."

p. 15807 l 24: missing "an": "... clouds has an altitude ..."

p. 15807/8 l 27-1: This sentence needs revision, because the message is doubled.

p. 15808 l 4: missing "a": "... with a decrease ..."

p. 15808 l 3-5: This sentence sounds awkward and needs a revision.

p. 15809 l 1: missing "the": "Albeit, the..."

p. 15809 l 25: change: "... but an insignificant trend..."

p. 15810 l 5: missing "the": "Albeit, the..."

p. 15811 l 3: Change to: "...September, a significant ... tropopause, while a few..."

p. 15811 l 14: Change to: "...thick cirrus clouds show a statistical..."

p. 15811 l 17: missing "the": "The climatology of the NARL lidar and the CALIOP..."

Figure 1: Please reduce the range of the xaxis in panel e and j to -0.1-0.3. Then the profiles and their differences are better discernible.

Figure 6a: It is maybe easier to see the distribution of optical thickness with a logarithmic xaxis.

Figure 9: Can you state in the Figure caption how the circles and error bars are determined (mean , median, standard deviation ?)

Figure 4,5,7,8,10: Caption should be changed to: "... showing the frequency distribution..."

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 15791, 2015.

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