Atmos. Chem. Phys. Discuss., 14, C3508–C3513, 2014
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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Satellite observations of cirrus clouds in the Northern Hemisphere lowermost stratosphere" *by* R. Spang et al.

**Anonymous Referee #1**

Received and published: 11 June 2014

This manuscript describes measurements of cirrus cloud top height (CTH) and water vapor by the space-borne CRISTA instrument over a one-week period in 1997. Comparisons are made with the CLaMS model. The authors conclude that there is a significant global population (northern hemisphere) of very thin cirrus lying above the tropopause in the lower most stratosphere (LMS). These measurements appear to confirm, on a global scale, previous ground-based lidar detections of the occurrence of LMS thin cirrus. Additionally, a previously undetected localized cloud occurrence frequency (COF) maximum is claimed to be present only in the tropics. The CRISTA LMS COFs are significantly larger than the ground-based COFs. CLaMS simulations show that the LMS cirrus are associated with outflow/mixing associated with Rossby wave breaking events.

My first reaction is why was this paper submitted to ACPD since the content is mainly of a technical nature that is more suitable for AMTD. I suggest some revisions and clarifications below.

A major concern is that a simple radiance color ratio i.e. the cloud index (CI) appears to be a fairly blunt tool for extracting this kind of detailed information on thin cirrus. Although, the CI works fine for general cloud detection there are limitations not addressed here. For example what is the discrimination between thin cirrus and aerosols? A single CI can only provide a threshold discrimination (regardless of particle type) although the expected distribution for CI from aerosols which almost certainly overlaps the CI distribution from thin cirrus is not discussed. How do we know that the LMS "bump" in the tropical CRISTA COFs is not stratospheric aerosol? The CRISTA CI COF are just compared directly with the CALIOP IWC COF. Potential differences between cloud detections using the CALIOP level 2 IWC (which I believe is screened for aerosols) and an analysis based on horizontally averaged level 1 backscatter is discussed by the authors only in the context of ultra thin cirrus.

The authors need to do more to convince the reader that 2-km vertical sample interval coupled with a 1.5 km field-of-view can yield reliable information on sub-kilometer thick clouds. No doubt that for an idealized unvarying unbroken train of cirrus the CTH from a limb sounder can be determined accurately. More convincing would be to take examples of contiguous CALIOP IWC profiles and run radiative transfer calculations for the CRISTA line of sight to simulate CRISTA CI values for a realistic "known" input. Even better would be to do the test with level 1 CALIOP backscatter data since the COFs for the two instruments are so discrepant in the tropics. So why not download the CALIOP data and make the appropriate comparisons? This is clearly relevant to the scope of the present work and results could be plotted in Fig 4 (which lacks a CALIOP comparison in the two bottom figures) instead of picking up a couple of plots from another publication (which is for a much longer 3 month composite JJA time frame).



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The authors state that the detection sensitivity "is linked to the detection threshold and depends to some extent on the seasonal variation in the trace gas concentrations in the applied spectral windows" (P12311:L16-19). This is a key point. However, note that there are also potential large vertical variations of water vapor within a single profile occuring near the tropopause. In fact located in the tropics, just above the tropopause, is the region known as the hygropause (e.g. Teitlebaum et al, GRL, 27, 211, 2000). Since the water vapor may be as low as 2 ppmv in this region it would be necessary to know if such a local H2O minimum could generate an apparent increase in the CI and therefore lead to a bump in the cloud occurrence fraction. On P12330:L20 we have CI = I(788:796) / I(832:834). The water vapor line used is given as 12.7 um on P12330:L20 (or 787.4 cm-1 and maybe affecting the numerator wavelength region) and since the CI value would presumably decrease along with with a decrease in water vapor (there are no strong H2O lines in the denominator wavenumber region) false positive cloud detections may ensue (i.e CI < CI_threshold). This issue can only be resolved by radiative transfer calculations.

/xxx/ ==> delete xxx

[xxx] ==> add xxx

P12325:L8 number concentration [and size distribution]

P12326:14 make it clear that the methane oxidation occurs higher in the stratosphere and that the resulting water vapor is transported downward

P12326:L20 discussed is so far quite controversial

P12327:L1 They find ... tropopause [than Dessler]

P12327:L15 micro/s/physical

P12328:L2 tropopause/./[?]

P12328:L5 vertical/ly/



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P12328:L6 such /a/ very

P12328:L17 Better to state the horizontal extents and vertical thicknesses here. i.e. what is the minimum thickness of the 100 km cirrus cloud and what is the minimum extended length of the 1 km thick cirrus detectable for these IWCs?

P12328:L20 So what is the CALIOP IWC detection limit (for the current data product)?

P12328:L22 /like to/

P12328:L26 [a]long track

P12329:L8 suggest/ing/[s]

P12332:L5 /are/ suggest/ing/

P12332:L15 is [a] matter

P12332:L17 quantify [accurately] ... /as good as possible/

P12335:L1 slant/ed/

P12335:L3 optical/ly/

P12335:L5 parameter[s]

P12335:L18 result/s/

P12335:L19 fals/ified/[e]

P12336:L1 indicat/ing/[e]

P12336:L8 /are/ suggest/ing/

P12337:L7 don't mix "km" and "m" units, just use "m"

P12340:L1 [for CI_thres=3] the tropics

P12340:L6 No significance testing is actually done here



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P12340:L9 described by [a]

P12340:L18 that /a/ statistical

P12341:L8 type of cloud/s/

P12341:L12 optical[ly] thick

P12341:L21 tak/en/[ing

P12342:L24 This should be refered to as a backscatter channel. CALIOP only measures backscatter for which the units are km-1 sr-1. However, the units given here are km-1 as for an extinction. Or was a lidar ratio for cirrus applied to obtain the extinction values? For CALIOP the extinction is a derived quantity which requires some assumption for the Lidar ratio (extinction-to-backscatter ratio) which depends on the particle type.

P12342:L26 I think you mean something like the IR limb sounder detection limit can be considerably better depending on the horizontal extent of the cloud. e.g. in the degenerate case a 1km long by 1km thick cloud would not practically yield a longer limb path than the nadir path.

P12342:L27 Again, better to state the horizontal extents and vertical thicknesses here. i.e. what is the minimum thickness of the 100 km cirrus cloud and what is the minimum extended length of the 1 km thick cirrus detectable for these IWCs? Why is this quoted again here (see P12328:L17 above) and why are the units now in mg m-3?

P12344:L10 it [may] create

P12344:L27 (in [the] direction /to/ [of]) *2 on this line

P12345:L2 nearly coincid/ing/[e]

P12350:L10 by [an] IR

P12350:L11 /to/ [as]



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P12351:L14 Has "RWB" been defined?

P12351:L23 includ/ing/[es]

P12352:L6-8 There is a "b)" but no "a)"

P12352:L13 hardly [able] to [be] improve[d]

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