Review of manuscript amt-2020-394 by Bartolome et al.,

The paper reports on the detection of optically thin cirrus clouds employing the novel midIR limb sounder GLORIA (Gimballed Limb Observer for Radiance Imaging of the Atmosphere). The measurements were performed during the airborne WISE (Wave-driven ISentropic Exchange) campaign over the Northern Atlantic in September/October. For the retrieval of macro-physical characteristics of the cirrus cloud two methods are employed, namely the colour index (CI) method comparing mean radiances measured in two micro-windows [I(788.2 cm^{-1})− I(796.2 cm^{-1})]/[I(832.4 cm^{-1} −I834.4 cm^{-1})] and the extinction method, which employs a full (spectral) retrieval of the received radiances in the micro-window 832.4 – 834.4 cm^{-1}. Both methods have been tested in the past, and accordingly it is found that both methods compare well within the given error range to infer the targeted macro-physical parameters (i.e. cloud top and bottom height, the vertical extend and the cirrus cloud extinction). The measurements are also used to tackle the question, as to whether cirrus clouds may eventually exist just above the tropopause, but the reported findings may not support an unambiguous conclusion on this matter.

The paper is generally well structured and thought-through and the contents is certainly suitable to be published in AMT. Nevertheless, I recommend to revise the manuscript with respect to some issues, as they are listed below. Also, I strongly feel the manuscript would deserve some polishing with the English, as well as in removing some technical and typographical deficits. A (probably not complete) list of these deficits is provided below, including some recommendations for improvements.

Comments

1. Page, line 7: *We developed an optimized cloud detection method and derived macro-physical characteristics of the detected cirrus clouds such as cloud top height, cloud top bottom height, vertical extent and cloud top position with respect to the tropopause.*

This sentences needs a revision in order to reflect the full range of parameters (c.f., the cloud extinction inferred at 833 cm^{-1}), which are inferred in the study.

2. Since it is well known that the (midIR) extinction of cirrus clouds is (weakly) wavelength dependent, which itself is a function of the particle shape and distribution et cetera (e.g., Van de Hulst 1957, Yang et al., 2001, Baran, 2005, and others), you will need to address this issue in the introduction in a few sentences and evenly important as a consequence to restrict all statements in manuscript referring to the extinction to the considered midIR wavelength/wavenumber range.

Refs:
- Van de Hulst, H. C. 1957 *Light scattering by small particles*. Wiley, New York, USA
- Yang et al., Radiative properties of cirrus clouds in the infrared (8–13μm) spectral region, Journal of Quantitative Spectroscopy &Radiative Transfer 70 (2001) 473–504
- Baran AJ., The dependence of cirrus infrared radiative properties on ice crystal geometry and shape of the size-distribution function, Q. J. R. Meteorol. Soc. (2005), 131, pp. 1129–1142

3. Somewhere (page 2, lines 13 and 14) in the introduction, it needs to be mentioned, which definition of the tropopause is used in the manuscript (in agreement with your sentence on page 12, line 26 'As discussed in Pan and Munchak (2011) different definitions of the tropopause can lead to different results.').
4. Page 12, line 5: We rather explain it by the differences in cirrus cloud selection criteria of the studies. Isn't it also a matter of detection sensitivity for the two set of observations, and

if yes, how would the inferred cloud fractions compare for the same detection threshold of the extinctions?

Technical, grammatical and typographical corrections

Note: Some of the recommendations for corrections as listed below are optional others are mandatory but all of them are meant to improve the readability of the manuscript. The direct citation from the manuscript is given in *italic*.

1. Throughout the manuscript, I found the arbitrary change in tenses (c.f. from simple past, to presence and vice versa) rather irritating. Check for internal consistency and the appropriateness for the used tenses.
2. Page 1, line 8: What is a 'cloud top bottom height'?
3. Page 2, line 30 and elsewhere: I wonder whether the notation of a ‚value' is really needed to describe the magnitude of a physical quantity, c.f. *This IWC value matches*…., instead of …. This IWC matches; in the Figure 3 legend: *CI value* instead of CI; page 11, line 3: *CI-values lower than 1.2* ... → CI lower than 1.2…. page 12,line 3: *These values*…→ These fractions ..; page 16, line 24: The corresponding TPmed and TP95 have close values → The altitude for corresponding TPmed and TP95 are close et cetera
4. Page 3, line 14. …. *of providing information* (of what?, c.f. on cirrus clouds) in the observation gap ….
5. Page 3, line 19: for measuring (what ?, c.f. microphysical parameters) of optically and vertically thin cirrus…..
6. Page 3, line 22: ….. horizontally averaged spectrum…. Mention here the size of the horizontal dimension/footprint over which it is averaged
7. Page 3, line 31: Table 1 summarizes the most important technical characteristics (→ features) of GLORIA
8. Page 4, Table 1 ledend: Observer altitude of 15 km and tangent altitude of 10 km. **Ungermann (2020, in preparation)* → (Ungermann et al., 2020, in prep.)
9. Page 4, line 1: Provide a reference (Hoffmann, 2006) for the RT model JURASSIC2 here
10. Page 5, line 1: define 'ice water content (IWC)' on the first occurrence in the manuscript.
11. Page 5, line 3: In addition, we retrieved the potential vorticity (PV) and equivalent latitudes…for consistency put latitude in singular, or potential vorticity into plural.
12. Page 7, equation 1: Check for the correct notation
13. Page 7, line 18: … as the percentile 95 and -86% (correct?)
14. Page 8, line 5: The range of retrievable extinction values for clouds→ The range of retrievable clouds extinctions …
15. Page 8, line 20*: If this gradient has a small variability, that means there are no elements that cause a sudden increase in the extinction.* Please reformulated this sentence in order to make better clear what is meant.
16. Page 8, line 31: *This value is similar ….*→ This detection limit is similar….
17. Page 8, line 34: *….. the low number of counts shifts (what counts?)…* → the low number of positive cirrus cloud detection ? ……..
18. Page 8, line 35: *This value, as well as the threshold for lower altitudes, agrees….* → Our threshold for this and lower altitudes, agrees
19. Page 9, line 6: *and vertical extent.* → and their vertical extent
20. Page 9; line 9: *which the extinction (or CI) has a value equal to or larger than the* k_{thres} → which the extinction (or CI) is equal to or larger than the k_{thres}
21. Page 10, line 4: ….*first point with an extinction* (what point? and to what refers first?) → ….first detection in the series of limb observations with an extinction…
22. Page 11, line 4: *Thin profiles*…. What are thin profiles? Profiles of small extinctions? …
23. Page 11, line 6: …..*reaches saturation after CI = 1.2* …(after?) → for CI's larger than 1.2.
24. Page 11, line 11: …*the different spectral slopes*..--> the different wavelength dependence…

25. Page 12, line 5: However, 60% is considerably…→ However, a fraction of 60% is considerably
26. Page 12, line 10: …….8 and 10 km present equivalent latitudes… → ….8 and 10 km as function of equivalent latitudes
27. Page 12, line 11: *For CTHs between 10km and about 12.5km the air masses have an equivalent latitude typical of mid-latitudes, whereas the highest CTHs, above about 12.5km are almost subtropical*.--> CTHs between 10km and about 12.5km often occur at equivalent latitude typical for mid-latitudes, whereas the CTHs above about 12.5 km, are (were) related to subtropical latitudes.
28. Page 12, line 13: *The main difference between both methods is the slightly higher (1 – 2 pixels) CTHs of the CI method.* → The main difference between both methods is the slightly higher (1 – 2 pixels) → CTHs inferred from the CI are slightly higher (1 – 2 pixels) than for the extinction method.
29. Page 12, line 14: *Considering all observed profiles about 39% are optically thick using the extinction and 41% the CI method.* → From all considered profiles, 39% can be characterized as optically thick (provide a number here) using the extinction method and 41% the CI method.
30. Page 12., line 14: *The maximum extinction detected for thin clouds in which a CBH was possible to determine is 4×10-2 km−1.* → For optically thin clouds, the maximum extinction at CBH was 4×10-2 km−1.
31. Page 12, line 20: *…the vertical extent distribution*→ the frequency distribution of the vertical extent
32. Page 12, line 22: … *computed*… → … found…
33. Page 12, line 27: … the first thermal tropopause altitude was computed from ERA5 data .. 'first' with respect to what?
34. Page 12, line 28: …. sampling air masses that can be heterogeneous. Consequently, the tropopause is usually not constant ..--> hence the sampled air masses can (could) be heterogeneous in the horizontal. Further, the tropopause height is (was) not constant.
35. Page 12, line 29: ….. *were applied*… → were used
36. Page 12, line 33: … *the air mass at 16:18 UTC is homogeneous*… → the air mass at 16:18 UTC was homogeneous (see my comment 1 above).
37. Legend 7: *PDFs of equivalent latitude (Eqlat) normalized for each altitude bin for (a) CTH detected with the extinction, (b) CTH detected with the CI and (c) CTH from ERA5. The altitude of the tangent points (TgPt) is the y axis* → PDFs of CTH as function of equivalent latitude (Eqlat) normalized for each altitude bin from (a) the extinction, (b) from the CI, and (c) from ERA5. The y axis shows the altitude of the tangent points (TgPt).
38. Page 13, line 1: … *there are heterogeneous*… → there were heterogeneous
39. Page 13, line 2: …. *since the CTH is above or below the tropopause depending on the chosen tropopause altitude.* → since as to whether the CTH is located above or below the tropopause depends on the chosen tropopause altitude. →
40. Page 13, line 11: …. both percentages decrease but still detect CBHs above the TP…→ both occurrences decrease but still CBHs above the TP are detected.
41. Page 13, line 12: *The presence of complete layers above the tropopause is inconclusive, as these CTHs and CBHs are in general just one altitude bin apart and the CBH is only one or two altitude bins above the tropopause, which is within the uncertainties of the CBH.* → The presence of complete layers above the tropopause is inconclusive, since for the cases CTHs and CBHs only separated by one altitude bin and the CBH is only one or two altitude bins above the tropopause, which is within the uncertainties of the CBH.
42. Page 14, line 5: *Spang et al. (2015) analysed CRISTA data (Spang et al., 2015) and concluded with a frequency of occurrence of 5% of all observations and Zou et al. (2020) obtained 2% for CALIPSO data and 4 – 5% for MIPAS data*. → Spang et al. (2015) analysed CRISTA data for cirrus clouds and concluded to a 5% their frequency of occurrence and Zou et al. (2020) inferred their occurrence to 2% for CALIPSO data and 4 – 5% for MIPAS data.
43. Page 14, line 7: …. *above the tropopause derived from ERA-Interim*.--> above the ERA-Interim thermal tropopause.

44. Page 14, line 9: *These values are comparable to the ones of the literature.* → These occurrence frequencies are comparable to those reported in the literature (provide references here).
45. Page 14, line 10: …. *ERA-Interim, the equivalent criterion would be 0.25 km above the tropopause.*--> ERA-Interim. Accordingly, an equivalent criterion would be to mandate the cirrus CTH to be located 0.25 km above the tropopause.
46. Page 14, line 12: *We explain the differences*… → We explain these differences…
47. Legend Figure 9: *The three profiles have been smoothed with a three points running mean.*--> The three profiles were smoothed with a three points running mean.
48. Table 2, legend: *Percentage with respect to all retrieved profiles of cloud top heights (CTHs) and cloud bottom heights (CBHs) detected above the median tropopause (TPmed) and the percentile 95 of the tropopause (TP95) for both detection methods*.--> Percentages of cloud top heights (CTHs) and cloud bottom heights (CBHs) detected above the median tropopause (TPmed) relative to all retrieved profiles and the percentile 95 for their occurrence above the tropopause (TP95) for both detection methods.
49. Page 16, lines 1 -3: *As explained in Sect. 2.3, one of the variables sampled following the viewing geometry of the GLORIA instrument is the IWC for ERA5, which when integrated along the LOS results in the limb IWP*.--> As explained in Sect. 2.3, one of the parameters sampled by GLORIA is IWP, which can be compared with the ERA5 reanalysis when the ERA 5 IWC is integrated along the LOS.
50. Page 16, line 5: ... *this is caused by the fact that for large* …> this is since for large particles …
51. Page 16, line 9: *Figure 7c shows a similar distribution of CTHs in ERA5 data as the one derived from the measurements* … --> Figure 7c shows a similar pattern of CTHs inferred from ERA5 data as those derived from the measurements.
52. Page 16, lines 9 – 11*: The fraction of CTHs detected in ERA5 is about 59% of all profiles, the same as the one of the CI method (59%) and only slightly lower than the fraction for the extinction method (61%).* → From all investigated profiles, the fraction of detected CTHs is 59% from ERA 5, 59% using the CI method, and 61% extinction method.
53. Page 16, line 12: …. *to not considering* … *which would mean increase the number of CTHs observed between 8 and 11 km* → discarding…. increases the number of CTHs incorrectly attributed to 8 and 11 km altitude range.
54. Page 16, line 17: …. *than for ERA5.* → than reanalysed in ERA5.
55. Page 16, line 17: *Considering all occurrences above the TP_{med}, the observations detect about 50% more than ERA5 data-set.* → When considering all occurrences of cirrus above the TP_{med}, the observations indicate 50% more cirrus clouds than found in ERA5.
56. Page 16, line 21: *In Sect. 4.2 the presence of complete layers above the tropopause was suggested*,… → The analysis presented in Sect. 4.2 suggest the presence of complete cirrus layers located above the tropopause.
57. Page 16, line 23: …. *Only cloudy points*… (what are cloudy points?) -> For both the extinction method and CI, measurements with a positive cloud detected are marked by colours.
58. Page 17, lines 1 – 3: *The CBH is slightly higher for the extinction method and above the tropopause, but still within the detection error, therefore, no affirmation of it being undoubtedly above the tropopause is made.* → For the extinction method, the CBH is located slightly higher than for the Ci method but still within the detection error. Therefore, the cirrus can't unambiguously be ascribed to locations above the tropopause.
59. Page 17, line 3: *In the location*… → At the location
60. Page 17, line 7: *These values of PV and N2 indicate*… → Therefore both the PV and N2 indicate…
61. Legend Figure 11: Describe the grey line (i.e. the flight trajectory).
62. Page 18, line 2: … *and the derived extinction* ..-> and the inferred extinction…
63. Page 18, line 3: … *and did not include*…→ and excluded
64. Page 18, line 5: …. *with an extinction of 2×10-4 km−1*….--> with an extinction as low as 2×10-4 km−1.