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Interactive comment on "Thin ice clouds in the Arctic: Cloud optical depth and particle size retrieved from ground-based thermal infrared radiometry" *by* Yann Blanchard et al.

Anonymous Referee #1

Received and published: 26 December 2016

General comments: The paper titled 'Thin ice clouds in the Arctic: Cloud optical depth and particle size retrieved from ground-based thermal infrared radiometry' presents a new retrieval algorithm to estimate cloud optical depth and separate TIC1 vs TIC2 clouds based on the effective particle diameter. The paper contributes to the remote sensing field, is within the scope of AMT, and builds upon existing work that is well-referenced but some additional details are required. Results and conclusions are presented clearly and overall the paper is well-structured. Prior to publication I have several comments which need to be addressed:

Specific comments:

-P.1-2: the introduction is well-structured but fairly brief. Please consider highlighting

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Discussion paper

the relevance and importance of these observations to other communities (satellite, modelers, etc.) by describing additional applications (e.g., reference the satellite cloud climatology project Klein and Jakob, 1999; Webb et al., 2001). Also, there have been previous studies using similar or even the very same instrumentation (FIRR, AERI) to measure the radiative effect of thin ice clouds. Describing these studies demonstrate the novelty of this paper's retrieval algorithm. See for instance Libois et al., 2016 (AMT), Blanchet et al., 2011 (SPIE), Mariani et al., 2012 (AMT), and related studies therein.

-P. 2 l. 1-2 and l. 22-24: these statements require references.

-P. 3 l. 1-5 these two statements require references.

-P. 3 l. 11: Table 1 only lists the instruments used in this study. There are many more instruments operating at Eureka. Please clarify this.

-P. 4 l. 5: is there a reference for the CIMEL? An instrument paper is needed for the reader to understand the technical capabilities of the instrument.

-P. 5 l. 6: why are the 10.2-10.9 and 11.8-13.2 channels not centered at the midpoint, but the other channels are? Please also clarify whether the exact same spectral ranges were used for the integrated P-AERI spectra.

-P. 5 l. 9-10: what are the implications of using P-AERI spectra to simulate CIMEL spectra? The impact of different spectral resolution, brightness temperature accuracy, instrument noise, and sampling time should be discussed. For instance, FIRR vs. AERI brightness temperature observations have statistically significant differences, possibly due to thermal affects. Is it possible to include results (if any) that indicate the level of agreement between the CIMEL and an AERI?

-P. 7 l. 9-11: the reference case listed in Table 2 has different cloud base height and thickness values than what is listed in the 'average' row, but in the paper it is stated that the reference case was the set of mean parameters. Please clarify.

-P. 7: the reference case was for Deff = 50 microns, which is a TIC2 cloud. Please

comment on results for a TIC 1 cloud with Deff < 30 microns.

-P. 7: this analysis is heavily dependent on MODTRAN'S ability to accurately simulate these cloud properties. Please comment on MODTRAN's reliability in this regard.

-P. 8 l. 20: WVC in the Arctic has a large influence on thermal IR measurements depending on the spectral region (e.g., large influence at 20 microns) and season. Please clarify this.

-P. 9-10: the discussion of errors requires extensive elaboration, particularly in order to defend the statement on p. 9 l. 2-4. For instance, the use of radiosonde data introduces several issues which need to be addressed, including: 1) dry bias, 2) impact of using soundings during cloud cover vs. clear sky on the retrieval, 3) interpolation of the +/-12 hour radiosonde profile. Errors associated with the OEM retrieval, such as the Sa, Se, and error covariance matrices, should be described (perhaps in the appendix) to provide a sense of the magnitude of these errors. The a priori and its covariance matrix must be carefully selected due to their large impact on the retrieval's outcome – more detail is needed here.

-P. 11 l. 9: please describe why this tolerance value was used.

-P. 11 l. 29: there are several papers that state the wavelength range of the P-AERI is up to 20 microns. Please clarify this discrepancy.

-P. 14 l. 14: on p. 10 it is states that upper and lower cloud boundaries are obtained where 7 vertical samples (52.5 m) comply with the backscatter requirement. Please clarify this discrepancy (52.5 vs. 200 m).

-P. 15 l. 1-2: please clarify what is meant by "sufficiently accurate."

-It would be interesting to see a comparison between MIXCRA and the Lidar-radar retrieval to provide a sense of how well the two established methodologies compare.

-P. 16 l. 15-on: please clarify whether "the comparison" is between MIXCRA and the

AHSRL Deff observations in the Turner and Eloranta paper and state their R-squared result.

-The results discussed regarding Fig. 9 are important and yet left out of the conclusion – consider including them.

Technical corrections:

-P.2 l. 8-9: the word 'properties' is used three times in ∼12 words.

-P.2 l.18-19: please consider reordering your examples so that the references are listed in chronological order.

-P.2 l. 27-29: the referenced work is not 'recent,' as your sources are 22 and 7 years old.

-P. 3 Eqn. 2: you have explained all variables except D^2.

-P. 4 Fig. 1: no date and observation time is provided in the figure caption. There is also no color bar legend and units.

-P. 5 l. 12: the list of references is not complete. If you are citing examples of studies, then state this using 'e.g.,'

-Fig. 2 and Fig. 4: the x-axis label 'lambda' should be changed to reflect what the physical quantity is, i.e., 'Wavelength.' The figure caption should clearly indicate whether this is simulated or observed values.

-Several places in the paper are missing a space. For instance, Table 2 caption, p. 7 l. 5, caption of Fig. 4.

-The text at the bottom right of Fig. 3 (b) should be moved into the figure caption.

-Fig. 4: please state the sample size of the simulation both in the figure caption and your discussion.

-P. 11 l. 10: "mean't" should be "meant."

-P. 12 l. 7: avoid nested brackets if possible.

-P. 12 l. 12: "and demonstrate that our retrieval produces give physically" – please fix.

-Fig. 6: titles should be moved next to the color bar (right-hand side). It should be clearly indicated that Fig. 6 (c) is Lidar-Radar retrieval in the figure and/or in the caption.

-Fig. 6: it is stated that only 8 of the 41 points from (b) passed the screening test. Please identify these points in the figure (perhaps a different color) and explain the distinction in the figure caption.

-Fig. 7: the equation (y=...) is missing in (b). The RMSE calculations are not shown in (b) and (d). The caption is also quite long – try to shorten and move parts to the discussion.

-P. 20 l. 16: 'Environment Canada' is now 'Environment and Climate Change Canada.'

-P. 22 l. 11-15 and p. 24 l. 10-13: these references are out of order based on publication year.