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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Assessing the impact of the Kuroshio Current on vertical cloud structure using CloudSat data" *by* Akira Yamauchi et al.

Anonymous Referee #2

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Atmospheric Chemistry and Physics Discussion: "Assessing the impact of the Kuroshio Current on vertical cloud structure using CloudSat data" Authors: A. Yamauchi, K. Kawamoto, A. Manda, and J. Li Manuscript Number: acp-2017-1134

This study uses four total months (May 15 – June 15 for 2007-2010) of CloudSat radar reflectivity data, rain profile data, and heating rates data to investigate the cloud and precipitation vertical structure near and adjacent to the Kuroshio Current, including the impact of the local warm waters and strong SST gradients during this late spring/early summer period. Complementary, collocated ECMWF-AUX reanalysis data are used for altitude and temperature profiles, and large-scale circulation data at a fine resolution, including profiles of vertical velocity, divergence, and winds come from the Japan Meteorological Agency's Mesoscale Model (MSM). The justification for this time pe-

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Discussion paper

riod is the strong SST gradients over the East China Sea (ECS), specifically the SST difference between the Kuroshio and non-Kuroshio areas, for which an SST threshold of 24°C separates the two regimes ("ON-Kuroshio" and "OFF-Kuroshio"). Maps of large-scale meteorological/climate variables are first presented, including dynamic and thermodynamic quantities of interest in and around the domain chosen, and then vertical profiles along a cross section of the domain are collected and shown. The presentation of the remainder of the study predominantly includes comparing cloud and dBZ profiles for the ON-Kuroshio and OFF-Kuroshio in a variety of ways, including PDFs of dBZ profiles, and then examining PDFs of different cloud types, including non-precipitating, drizzle, and precipitating regimes. The main take-away message is that rain intensity in the mid-troposphere is stronger over the defined Kuroshio regime versus surrounding areas, with a greater frequency of precipitation from geometrically thick clouds over ON-Kuroshio. Even in drizzling and non-precipitating clouds, the authors show a slight increase of the altitude of dBZmax in ON-Kuroshio profiles. All-in-all, despite the effort by the authors to separate the Kuroshio-influenced atmosphere from the adjacent areas in documenting possible vertical cloud structure differences using active radar and some auxiliary data, the limited amount of data analyzed, only four total months, is unfortunately a significant shortcoming of this study. CloudSat already suffers from sampling rather sparse data, due to the inherent thin curtain nature of its sampling, and collecting only one month per year of data arguably does not provide a significant-enough sample size for which to draw more robust conclusions. Indeed, the data striping in Figure 2 of profiles of cloud fraction, cloud water content, precipitating liquid/ice water content, and total water content, as well as the structures of longwave and shortwave heating rates, underscore that some areas of the cross section do not even get sampled out of the total of four months assessed. This is indeed problematic, and it's difficult to draw any meaningful conclusions from any of the CloudSat-borne quantities in that figure, save perhaps for the discrimination of net heating versus cooling rate profiles (panel k). The authors rationalize the one-month per year analysis because of the maximum strength of SST gradients, but how about at least doubling that (April 15 – July 15), and then possibly adding more years as well? The goal needs to be at least the minimum of profiles that would provide full coverage and remove the striping for the profile analysis in Fig. 2, which at this time, except for the large-scale variables (e.g. convergence, vertical velocity, and RH), has little significance for the study. It may be helpful to bring in other A-Train datasets, such as Aqua MODIS data, to provide additional information about cloud fraction, cloud optical depth, vertical structure, and perhaps even effective radius. The latter could be quite beneficial in particular to help quantify the relationships between the radar reflectivity and radius between ON-Kuroshio and OFF-Kuroshio, particularly as they may relate to the results shown in Figs. 3 – 5. Furthermore, given that CloudSat becomes attenuated at ∼15 dBZ, it may be useful to include a sensor which provides precipitation for more heavily raining clouds, such as AMSR-E, to pin down the differences particularly for some of the deeper convection periods captured in this study. Bringing in AMSR-E would allow a more quantitative analysis of the contribution of different cloud heights to total precipitation between ON-Kuroshio and OFF-Kuroshio. A useful exercise may be compositing against altitude of dBZ_max in both regimes; if altitude is normalized then the explicit role of surface conditions and large-scale vertical velocity in Kuroshio versus OFF-Kuroshio could be analyzed. Similarly, examining the vertical structure against different rain rate categories in a more holistic way may be more satisfying than the one-category only now ("precipitating" category), and would provide potential physical insights as well as useful information for climate model parameterizations. The authors should also consider performing analyses of cloud vertical structure, vertical velocity, and some other pertinent cloud properties already shown as a function of SST. There may be no need to partition Kuroshio versus adjacent areas, as SST itself may naturally distill the results. Finally, the manuscript needs to be proofread by a professional English editor, as the tenses (e.g. past and present) jump around improperly; indeed most of the study should be in the present tense, but much of it is in past tense. A few explicit examples of this are provided at the very end of this review, as well as a non-exhaustive list of grammatical errors and typos. Overall, this paper may eventually be publishable, but it will require extensive and major revisions, as well as additional data, for it to be a sufficiently complete study.

Specific Comments: 1. Figure 1: The yellow box, representing the target region, as well as the sub-domain represented by the thick-dashed box, should be shown in each panel of Figure 1, which would aid the reader in orientating the main features more readily from each of the fields displayed. Again, adding considerably more data, and possibly MODIS cloud fraction, would make Fig. 1f much more meaningful than it is now, which stands currently as a fairly chaotic field of cloud fraction due to the noisiness. Please also consider an improved color scheme, especially for Fig. 1d, which shows the skin temperature. The gradations are very subtle between about 23°-26°C, even though this encompasses the critical threshold for defining ON-Kuroshio and OFF-Kuroshio. 2) Figure 2: As stated in the summary and overarching comments at the beginning of this review, many of the CloudSat-derived or retrieved profiles are almost meaningless here, partly because of the sparse and limited sampling (with data striping!), and perhaps in some cases, because of the color schemes chosen. For the SW HR, LW HR, and Net HR plots, while it is possible to distinguish between reds (warming) and blues (cooling), it is very difficult to discern the seemingly more subtle differences across the cross section analyzed. Also, there appears to be an inconsistency between the manuscript text and the caption in Figure 2 – the latter states the thick dotted box between (25-34N, 126.5-131E), but the figures themselves show longitude values between 120 – 131E, as does the box itself in Fig. 1. Also, the latitude range from Fig. 1 is 28-31.5N, which is also stated in the text body, but this is different from the caption of Fig. 2. Please correct. 3) Line 3, page 4: Please consider adding "Frisch et al. 1995" for an additional, more historical citation – e.g. this is an early paper which uses -15 dBZ to discriminate between non-drizzling and drizzling/precipitating clouds. Reference: Frisch, A. S., C. W. Fairall, and J. B. Snider, 1995: Measurement of stratus cloud and drizzle parameters in ASTEX with a Ka-band Dopper radar and a microwave radiometer. J. Atmos. Sci., 52, 2788-2799. 4) Line 8, page 5: The sentence: "The total water content (TWC: CWC+PLWC+PIWC) corresponded to LTS, which peaked around 124.5E", is very vague and confusing, and needs to be rewritten. 5) Line 18, page 5: The phrase, "As previously described, TWC increased over the Kuroshio" is rather difficult for me to discern from Fig. 2k. Perhaps the black striping and the color scheme make this result a difficult one to view. In another vein, if the authors decide to assess any other A-Train data, examining cloud radiative forcing in a similar way from CERES, including Longwave, Shortwave, and net, might be complementary to Figure 2 and the paper in general. The real question is – do clouds over the Kuroshio have a larger net TOA radiative effect? Profiles of cloud radiative effects can also be assessed from CERES, if there is space to perform this analysis. 6) Lines 4-5, page 6: Please consider re-writing the sentence as follows: "These results show that clouds with the highest rainfall intensity measurable by CloudSat at lower altitudes (1-6 km) are common in the target region." 7) Lines 4-7, page 7: Why are mid-thickness drizzling clouds more abundant in the OFF-Kuroshio region (Fig. 4b)? Is this because the ascending motion is weaker and more bottom-heavy than over the Kuroshio current, leading to a greater abundance presumably of mid-level clouds? This is also the case for precipitating clouds; mid-thickness clouds are more pervasive in the OFF-Kuroshio regions. Can we say anything about total precipitation from this Figure (or Figure 5)? It would be interesting to know how much the different categories contribute to total precipitation, and this is where an independent, additional sensor which does not attenuate for dBZ>15 dBZ would be helpful, such as AMSR-E. 8) Lines 25-26, page 7: "...taking 0 and 1 at the cloud top and the cloud base, respectively..." There's no need to repeat this here, as it is already explicitly described at the beginning of that paragraph.

Grammatical Suggestions and an Incomplete List of Typos (Please have a professional English editor carefully proof this manuscript) 1) As an illustration of the tense problem reported above, Lines 6-10, page 3 are in past tense, but this is inappropriate as it discusses the organizational structure of the paper – e.g. should instead be: "In section 2, we show the data ... In section 3.1, we describe the influence...". The authors seesaw between past and present tense, sometimes opening paragraphs in present tense, but then reverting to past tense by mid-paragraph. Please correct this – it happens during so many instances that it's not convenient to enumerate them all here. 2) Line 1, page 5: change "less than" to "west of" 3) Line 4, page 6: add "over" before "both" 4) Line 20, page 8: a period is missing after "ON Kuroshio". 5) Line 21, page 8: change "updraft" to "updrafts"

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