Response to Reviewer #1 of acp-2014-213

Dear Reviewer,

Thank you very much for taking your time to review our paper.
I am returning herewith a manuscript revised according to reviewers' comments.
I hope that the manuscript is now acceptable for publication in *ACP*.

[RC]: Referee comment in *Italic*
[AC]: Author comment

General Comments

[RC] *This paper repeats several recent global scale analyses based on CloudSat and MODIS data in specific regions in the midlatitude Pacific ocean and the Eastern Asian continent. Mostly the methodology borrows from Kubar et al., 09 and Suzuki et al, 10. Findings on these regional scales tend to be similar to those found on the global scale. The methodology and analyses is generally sound while the interpretation is slightly suspect in a few areas outlined below. The paper doesn't add very much to the prior studies from which it borrows. There are interesting differences between land and ocean results which could be an area that could be much more thoroughly explored. This could be a fruitful area for the authors to explore in the future.*

I recommend that the paper requires minor revision prior to publication.

[AC] We would like to thank the referee #1 for his/her very insightful comments, which make our manuscript better. Our discussion and corrections on individual issues are below.

Minor Comments:

[RC1] *Page 5, Line 4: State that the cloudmask = 30 is from the Geoprof mask. Only very few people will know what mask = 30 means.*
[AC1] CloudSat cloudmask value greater than 30 means good/strong echo, which estimated false detection less than 4.3% (Marchand et al. 2008), therefore high confidence is guaranteed.
We have changed this sentence slightly, "a cloud mask value greater than 30, which means high-confidence detection," to "a cloud mask value greater than 30 (good/strong echo), which means high-confidence detection (estimated false detection < 4.3%; see Marchand et al., 2008, Table 1),".

[RC2] *Page 7: The results for the inland industrial areas are very non-intuitive. Land or ocean one would expect precipitation occurrence to map most strongly into LWP based on simple microphysical arguments. Whether it be land or ocean, the Another plausible explanation might be that there are errors in the retrieval algorithms. Perhaps the cloud types are different over the industrial areas. I would think that there would be more cumulus than over the ocean. MODIS retrievals for cumulus clouds are much more prone to retrieval errors than are stratocumulus because of the horizontal inhomogeneity. See the recent publications from Zhibo Zhang for example.*
[AC2] Thank you for your helpful advices and suggestion. Following short discussion of cloud types and the MODIS retrieve error have been added in the first paragraph of section 3.1: "The results suggested that the precipitation occurrence is most strongly related to LWP, except for the Industrial area. It is noteworthy that there are large seasonal differences of more than 7 K in

LTSS in the Industrial area. Therefore, there is a possibility of different cloud types over the Industrial area; i.e., more cumulative cloud in JJA (unstable lower LTSS environment) than over the oceanic area. The passive MODIS sensor tends to retrieve errors on cumulative inhomogeneous cloud (e.g., Zhang et al., 2012; Zhang and Platnick 2011; Zinner et al., 2010) because of its simplifying assumptions; i.e., clouds are plane-parallel and homogeneous, any effects of drizzle/rain drops are ignored (Zinner et al., 2010), etc. These assumptions may lead to retrieval bias of CDR; e.g., illumination (shadowing) effects can lead to overestimation (underestimation) of COT and underestimation (overestimation) of CDR (Marshak et al., 2006). The larger CDR and smaller COT are estimated with increasing cloud inhomogeneity, which results in underestimation of LWP for cloudy scenes (Painemal et al., 2013). Therefore, care should be taken with regard to this background of CDR retrieval error and underestimation of LWP, especially over the Industrial area in JJA.".

[RC3] *Page 9, Line 6: The differences in LWP do not necessarily mean the cloud lifetime increases. Without a really good causal mechanism and a lot more analysis you shouldn't speculate about this.*
[AC3] Yes. We see your point. Kubar et al. (2009) well documented the drizzle occurrence by using LWP-N_c diagram (see their figure 12), as we mentioned in our discussion paper. Their results showed that the drizzle frequency decreases with increasing N_c under constant LWP, which partly indicates aerosols second indirect effect (see also Leon et al., 2008, figures 8 and 10). In our results as well, similar characteristics were generally observed, though using not drizzle occurrences but Z_{max} to know drizzle/precipitation intensity in our analysis. We think that our suggestions about the possibility of cloud lifetime are important. We tried to emphasize the cloud lifetime effect associated with LWP and N_c by our method for the contrast of aerosols concentration (land versus ocean), but indeed, our first try of seasonal/regional analysis to understand aerosol–cloud interaction need further work.

[RC4] *Page 9: CloudSat cannot reliably measure cloud thickness. There are two problems. First for precipitating clouds there are reflectivity values that are from precipitation, not cloud. Second for non-precipitating clouds, the reflectivity at cloud base are most likely too weak to be observed. You need to mention these things. What you are really measuring is the hydrometeor thickness subject to the minimum detectable signal of the CloudSat radar.*
[AC4] It is a very important point. Thank you for your suggestion. According to your comment, we have added a few sentences to explain the notice and information, at the end of the first paragraph of section 3.4: "However, it should be noted that the "cloud geometrical thickness" mentioned here does not always accurately represent the cloud thickness. Specifically, in some cases of non-precipitating cloud, determination of the cloud base is difficult because the reflectivity at this point is too weak to be observed. However, in the case of precipitating cloud, the detected value would include not only the cloud but also some of the precipitating layer. Thus, the "cloud geometrical thickness" represents the detected hydrometer thickness.".

[RC5] *Page 10, Line 19: cloud growth is insensitive to LTSS. I think that you have this backwards.*
[AC5] Needless to say, the atmospheric stability, especially updraft velocity is a very important factor for cloud/drizzle/rain droplet growth. What we really wanted to express is, the CDR is a more dominant factor than LTSS, presented in figure 8.

Thank you very much for reviewing our paper.

References

Marchand, R., Mace, G. G., Ackerman, T., and Stephens, G. (2008), Hydrometeor detection using CloudSat – an Earth-orbiting 94-GHz cloud radar, J. Atmos. Ocean. Technol., 25, 519–533, doi:10.1175/2007JTECHA1006.1.

Zhang, Z., A. S. Ackerman, G. Feingold, S. Platnick, R. Pincus, and H. Xue (2012), Effects of cloud horizontal inhomogeneity and drizzle on remote sensing of cloud droplet effective radius: Case studies based on large-eddy simulations, J. Geophys. Res., 117, D19208, doi:10.1029/2012JD017655.

Zhang, Z., and S. Platnick (2011), An assessment of differences between cloud effective particle radius retrievals for marine water clouds from three MODIS spectral bands, J. Geophys. Res., 116, D20215, doi:10.1029/2011JD016216.

Zinner, T., G. Wind, S. Platnick, and a. S. Ackerman (2010), Testing remote sensing on artificial observations: impact of drizzle and 3-D cloud structure on effective radius retrievals, Atmos. Chem. Phys., 10, 9535–9549, doi:10.5194/acp-10-9535-2010.

Marshak, A., S. Platnick, T. Varnai, G. Wen, and R. F. Cahalan (2006), Impact of three-dimensional radiative effects on satellite retrievals of cloud droplet sizes, J. Geophys. Res., 111, D09207, doi:10.1029/2005JD006686.

Painemal, D., P. Minnis, and S. Sun-Mack (2013), The impact of horizontal heterogeneities, cloud fraction, and liquid water path on warm cloud effective radii from CERES-like Aqua MODIS retrievals, Atmos. Chem. Phys., 13, 9997–10,003, doi:10.5194/ acp-13-9997-2013.

Kubar, T. L., Hartmann, D. L., and Wood, R. (2009), Understanding the importance of microphysics and macrophysics for warmrain in marine low clouds, Part I: Satellite observations, J. Atmos. Sci., 66, 2953–2972, doi:10.1175/2009JAS3071.1.

Leon, D. C.,Wang, Z., and Liu, D. (2008), Climatology of drizzle in marine boundary layer clouds based on 1 year of data from CloudSat and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO), J. Geophys. Res., 113, D00A14, doi:10.1029/2008JD009835.