

Review of v2 of Bennartz and Rausch – “Global and regional estimates of warm cloud droplet number concentration based on 13 years of AQUA-MODIS observations”

We thank the authors for addressing most of the comments. I feel that a few of the issues need a bit more attention, though :-

Uncertainty analysis

The new section does somewhat clear up the matter of the uncertainty vs variability, particularly for the stratocumulus regions where the overall variability (i.e. actual variability + instrument uncertainty) is smaller than the instrument uncertainty alone. It is now helpful that the meaning of the uncertainty is made clear in the paper.

Although, this raises the issue of systematic errors/offsets vs random uncertainties. The use of the instrument uncertainties from MODIS (which are just the radiance uncertainties propagated through to τ_{eff} and τ) neglects uncertainties in the forward model relating to heterogeneity, etc. This might produce a fairly constant offset error in N_d , which would therefore not show up as variability in the standard deviation. In the current paper the propagation of errors in τ_{eff} , etc. through to N_d that was done in Bennartz (2007) is mentioned – such an analysis might do a better job of estimating such offset errors to give a better estimate of how far off the quoted N_d values are from reality. However, they don't seem to be used in the current work. I think that it would be good to mention the possibility of such “offset errors” and to quote the uncertainty range calculated in Bennartz (2007).

Solar Zenith Angle dependence

p.7, L31 – “Conversely, at high solar zenith angle also the effective radius at $3.7\ \mu\text{m}$ might also be biased leading to possible increases in CDNC by 40% to 70% at solar zenith angles higher than about 70 degrees (Grosvenor and Wood, 2014).”

This doesn't quite address what I was trying to convey with my review comment. Firstly, Grosvenor and Wood (2014) showed that optical depth biases were mainly responsible for the 40-70% increase in CDNC. I think that a sentence like this should be moved to p.9, L15 where you talk about the view geometry biases. There, instead of “Grosvenor and Wood (2014) address the dependency of cloud microphysical retrievals on solar zenith angle. ”, you could perhaps write :-

“Grosvenor and Wood (2014) address the dependency of cloud microphysical retrievals on solar zenith angle demonstrating a possible increases in CDNC by 40% to 70% at solar zenith angles higher than about 70 degrees.”

Then on p.7 something like this would be more akin to what I meant :-

“However, at high solar zenith angles Grosvenor and Wood (2014) demonstrated that resolved (as opposed to sub-pixel) 3D radiative effects are likely to cause the effective radius to be biased high, with larger biases expected for the 3.7 μm retrieval compared to the 1.6 μm one.”

Sampling in regional boxes

From your response:-

“We are not too concerned with the data density. Recall that only grid-boxes with at least ten days per month with at least 10 observations each make it into the climatology. Those were then averaged to get the average values for each of the larger boxes like X12. Thus each box has virtually hundreds of observations in it.”

However, there may be few 1x1 degree grid boxes that are included in the region X12 for a given month, and this will vary by month. It would be useful to check what these numbers look like and to quote them in the paper.

Issues RE “Specific comments”

p.3, L19 – “as ultimately one would be interested in the number of cloud droplets activated at cloud base and not the number of cloud droplets observed” – *I think this would depend on the application. Some studies may be interested in how the cloud top CDNC might change due to lateral mixing, evaporation, etc., or removal of CDNC by precipitation and not necessarily just the cloud base CDNC. I can see that the cloud base CDNC would be of interest for comparing to model processes, but I think that the statement here generalizes too much.*

This does not seem to have been addressed.

Typos

p.5, L6 - “MODI derived”.

p.6, L11 – No need for the commas here.

P13, L7 – “Out lined”

Fig. 8 seems to have no caption.

p.16, L18 – “consisntent ”

p.16, L24 – “our artefacts”

p.16, L26 – “itself” should be “themselves”.

P17, L4 - “by directly” should be “directly by”

p.16, L21 :- “Further retrieval issue might arise at **high zenith** angles and/or near the ice edge. At **high zenith** angles, earlier work by Grosvenor and Wood (2014) showed the effective radius at 3.7 μm to be more strongly biased, potentially leading to retrieval issues.”

– should include “solar” before “zenith” in both instances.

p.12, L25 – “observe” should be “observed”.