

Review: Validation of MODIS cloud microphysical properties with in situ measurements over the Southeast Pacific. Q. Min et al. ACPD

Min et al. compare MODIS cloud microphysics against aircraft observations sampled during VOCALS-REx. MODIS variables are relatively well correlated with in-situ observation, although the cloud effective radius (r_e) is overestimated for almost 1.8 microns. The authors argue that the adiabaticity and the algorithm assumptions about the cloud vertical structure are main aspects to be taken into account when searching for plausible explanations for the MODIS bias.

While validation analyses like Min et al. are valuable, especially considering the scarcity of in-situ observations in marine stratocumulus, I have major concerns about this manuscript. A recent paper by Painemal and Zuidema (2011, JGR) carried out a similar analysis using basically the same C130 measurements as in Min et al., but including a more comprehensive description of the cloud vertical structure and a better analysis and discussion of the possible errors sources that might explain the MODIS biases including: water vapor path effect, breadth of the droplet size distribution, thermal emissions, and 3D radiative effects. Painemal and Zuidema (PZ11) also investigated MODIS r_e based on 3.7 μm , and 1.6 μm radiances. In addition, they also assessed the significance of their results considering errors in the in-situ probes.

I believe that the current manuscript does not show meaningful results that justify publication.

Major comments:

1. The authors partially repeat the analysis performed by PZ11. I suspect that most of the analyzed samples come from the C-130 aircraft. Hence, it is not surprising that Min et al. find similar results as PZ11. If the authors want to further confirm the findings in PZ11, then they should use an independent dataset, excluding C-130 observations and including additional VOCALS-REx aircraft observations.

2. Min et al. ignore the fact that the vertical penetration of photons depends on the wavelengths used to retrieve r_e (Platnick, 2000). Platnick (2000, JGR) explicitly shows that the statement in p1425, line 19-20 is misleading. Hence, the three different MODIS r_e (2.1, 1.6, and 3.7 μm) have to be studied if one wants to determine the consistency among photon penetration, vertical structure, and r_e .

It is also mentioned in p1425 that the mean r_e is 5/6 of the cloud top adiabatic r_e . This statement is incorrect, and it is obtained from the following assumption:

The liquid water path (LWP) for a vertically homogeneous cloud is:

$$LWP_H = \frac{2}{3} \rho_w \cdot r_{e_H} \cdot \tau \quad (1)$$

and for an adiabatically stratified cloud (or r_e and water content linearly increasing with height) as:

$$LWP_s = \frac{5}{9} \rho_w \cdot r_{e_s} \cdot \tau \quad (2)$$

with ρ_w the water density, τ the cloud optical thickness, r_{eH} the homogeneous r_e , and r_{es} is at the cloud top. If LWP's and τ 's are equal with (1)=(2), then:

$$r_{eH} = \frac{3 \cdot 5}{2 \cdot 9} r_{es}$$

$$r_{eH} = \frac{5}{6} r_{es}$$

The question is why the stratified and homogeneous LWP should be equal? The “unphysical” adjustment would come from r_e then. Therefore, I think the factor 5/6 is incorrect from a microphysical and remote sensing point of view. This factor is constantly used to represent some sort of equivalent r_e but, again, I believe this is wrong; in fact it makes much more difficult interpreting the figures.

3. The sub-adiabaticity analysis is not statistically significant. A close look at the figures does not reveal any significant change between adiabatic and subadiabatic samples. Why the sub-adiabaticity should affect the retrievals? In terms of the photons vertical penetration, how changes in the vertical structure (induced by cloud top mixing) can affect the retrievals? A more careful investigation requires analyzing the cloud vertical profiles in terms of sub-adiabaticity. This should be easy to do since the number of profiles used is only fifteen.

4. Section 4 is not novel. The authors carried out RT simulations for vertically stratified clouds (either adiabatic or sub-adiabatic) and then retrieved the cloud properties using a vertically homogeneous model. Nakajima and King (1990, J. Atmos. Sc.) already documented in detail the main findings in Section 4. Nakajima and King. also retrieved r_e for adiabatic clouds, using a vertically homogeneous model (constant r_e), finding that the retrieved r_e was “smaller” than the cloud top r_e . I believe this is exactly what Min et al. found in their analysis (if one gets rid of the 5/6 factor). In other words, the MODIS positive bias “cannot” be accounted for the use of a vertically uniform model.

The reason why LWP VUPPM overestimates LWP ASPPM in Fig. 10c is because Min et al. used equation 1 (above) to calculate it. If they use equation (2) (above), then they would find that LWP ASPPM > LWP VUPPM in Figure 10c. (Note that the CDNC formula is based on LWP_S)

5. The authors seem to use all the available MODIS retrievals. I suspect that a rigorous screening based on cloud fraction would yield a better agreement. I would imagine that if the analysis includes all the samples, some MODIS scenes would be severely affected by clear sky contamination.

6. P1432 lines 1-3. I disagree. The figure does not show any dependence on adiabaticity A. The cloud geometrical thickness dependence is actually dependence on the cloud optical thickness in the look-up table. The vertical profile of effective radius

and the cloud optical depth within the cloud are the variables that affect the retrievals, rather than the geometrical thickness.

7. Discussions in Platnick and Valero (1995, J. Atmos. Sc.) and PZ11 show that there are many potential sources of uncertainties. Most of them are ignored by Min et al

Other Comments:

- Cloud top temperature comparison: Zuidema et al. (2009, J. Clim.) reported similar results using MODIS and radiosonde observations with a more comprehensive dataset.
- Validation analysis during VOCALS-REx by Zheng et al. (2011, ACP) should also be considered by Min et al. Zheng et al., using Twin Otter aircraft observations, showed that MODIS r_e overestimates the in-situ r_e .
- P1423, I am not sure that the copper smelters are the main sources of aerosols (VOCALS-REx ACP publications should help elucidate this point).
- Why Aqua observations are not included?
- P1430, why a 1.65 degrees bias in cloud top temp. is equivalent to 200 m?
- King et al. (1997) is not in the references.
- P1434 change “humility”, and “metrological”.
- PZ11 show that the bias increases with r_e . This is equivalent to a bias dependence on CDNC and cloud thickness found by Min et al.
- I do not understand why the authors exclude the precipitating cases from their analysis. Those cases should also provide interesting results, especially because precipitation is sometimes parameterized as a function of r_e (e.g. Wood et al., 2008, JGR).