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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Evaluating MODIS cloud retrievals with in situ observations from VOCALS-REx" *by* N. J. King et al.

Anonymous Referee #3

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This paper uses in situ measurements taken during VOCALS-Rex to evaluate MODIS-derived cloud optical thickness, liquid water path, and particle size. The in situ measurements are taken by Cloud Droplet Prove (CDP) and two dimensional stereo prove for particle size 2 to 50 micron diameter. The uncertainty of in situ particle size measurements is estimated as 1 micron by comparing two similar measurements. The result shows that MODIS derived optical thickness, LWP, and particle size derived from 1.6, 2.1, and 3.7 are larger than in situ measurements. The in situ observations do not support the presence of small particle at the cloud top. In addition, larger particle size derived from 2.1 micron than 3.7 micron is not explained by the vertical distribution of observed particle size. The authors also conclude that 3D effects are not enough to give a large enough difference of MODIS-derived and in situ observations. The paper presents that the particle size derived from 3 different wavelengths does

not contain the information of vertical distribution of particle within clouds as opposed earlier studies that claim the vertical particle size profile can be derived using multiple wavelengths. Whether such information can be derived from multiple wavelengths should be debated through peer-reviewed journal. I, therefore, recommend publishing the paper after a minor revision. My minor comments follow.

A larger optical depth and larger particle size derived from MODIS compared to in situ observations do not theoretically make sense. If the optical depth derived from a non-absorbing wavelength is too large, a smaller particle size is needed to give the required absorption in near-IR. I mean by required here is that the same amount of absorption computed with particle size derived from in the situ observations. If a plane parallel cloud assumption holds, a thicker optical thickness and a larger particle size give too low near IR reflectance compared with near IR radiance observed by MODIS. Therefore, this paper's result indicates that MODIS radiances at visible wavelength, and other three near IR wavelengths cannot be simulated (i.e. modeled radiances for all four wavelengths do not agree with MODIS observation) using cloud propertied derived from the in situ measurements. A similar argument has been used to understand large MODIS derived cloud particles in earlier studies. If a retrieved optical thickness is too small, cloud particle size must be larger to obtain the same amount of absorption in near IR (i.e. to match MODIS near IR radiances), which is pointed out by Coakley et al. (2005, J. Atmos. Oceanic Technol. 22 3-17) and Kato et al. (2006, J. Geophys. Res. 111, doi:10.1029/2005JD006668). But this result shows that both optical depth and particle size are larger, which is not explained by 1D radiative transfer theory. The authors mentioned that 3D effects do not explain the observed difference either. If in situ derived cloud properties were used in radiance computations, modeled radiances are not likely to match radiances at 4 MODIS wavelengths. I cannot tell what causes this apparently a fundamental mismatch or whether this affects the analysis shown, for example, Figure 8 from the information given in the paper. The authors need to mention this inconsistency before discussing that no vertical particle size profile information can be derived from 3 near IR MODIS channels. They also need to explain that

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the discrepancy is not caused by, for example, computation of cloud optical depth or effective radius from in situ conservations.

The authors do not describe cloud fields and environmental conditions that these 13 flights were taken place. Are clouds horizontally uniform, overcast and single layer (no cirrus above)? What were solar zenith angles and MODIS viewing angles? Including MODIS viewing geometry provides information that gives a clue to the mystery.

Adding above information makes the paper even longer from the current length, which might already be too long. But the authors can shorten current version significantly. Foe example, the sentence appears on page 23698 line 16 is repeated at lest three times in the paper. The current version needs significant editing to avoid going similar discussion over and over. In addition, there are several incomplete sentences and sentences that are too long.

Page 23692 line 17 Rt is defined as the particle size at 1 km below the cloud top. Please explain why r3.7 is substituted for rt.

Page 23702 line 25 Optical absorption. Is what the authors meant simply “absorption”?

Figure 1 The x label needs to be normalized standard deviation.

Figures 2, 6, 10, and 12 are too small and hard to see.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 23679, 2012.