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Interactive comment on "Validation of MODIS cloud microphysical properties with in situ measurements over the Southeast Pacific" *by* Q. Min et al.

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The MODIS operational cloud effective radius retrievals over the South-East Pacific region are compared against the in situ measurements from the VOCALS campaign. For the 17 non-drizzling cases selected, MODIS retrievals are found to overestimate in situ observations by 1$\sim$2μm. The origin of this bias is discussed and attributed to cloud vertical stratification from the condensation growth.

General comments It has been a frustrating problem for cloud parameterization teams that the GCM simulation of warm cloud effective radius is often about 5μm smaller than MODIS retrieval (e.g. Donner et al. 2011 J. Climate, Kay et al. 2012 J. Climate). Several recent papers (e.g., Nakajima et al. 2011 JAS, Seethala and Horváth 2010 JGR,

Zhang and Platnick 2011 JGR) revealed substantial (5$\sim$10μm) uncertainties in MODIS effective radius retrievals. All these studies indicate satellite-based remote sensing of cloud microphysics, even for the simplest cloud system, is still highly uncertainty. In situ measurements from field campaigns, like VOCALS, provide valuable observations to address this uncertainty. This manuscript documents an investigation of MODIS effective radius retrieval uncertainty based on VOCALS measurements. Although such investigation is much needed, I feel a little disappointed after reading the manuscript. The hypothesis (i.e., cloud vertical structure due to condensation growth) raised by the authors to explain the difference between MODIS and in situ measurements are well-known and well-discussed in the literature. Moreover, the evidences showed in this paper are not convincing enough to justify this hypothesis and other possibilities are not well discussed.

On the other hand, I think this manuscript may be useful contribution to the ACP special issue, as it documents the VOCALS cloud microphysics measurement cases suitable for comparing to satellite observations. Overall, I feel it needs to be considerably improved before it can be considered for ACP. Below are my comments on the manuscript and some suggestions for the authors.

Major concerns:

First of all, I don't think this study is really a "Validation of MODIS" retrievals. It is more of a comparison study. This is because MODIS retrievals and the in situ measurements presented in this study are too different in too many respects, including spatial and temporal sampling, theoretical bases and practical implementation. Although some attempts have been made to reduce these differences, I am still not convinced that it is an apple-to-apple comparison. These cases may be excellent for cloud microphysics studies, but they are not good cases for satellite validation. A well-planned validation campaign would have avoided these complications. I suggest the author reconsider the title. A more suitable one seems to be" Comparison of MODIS cloud microphysical properties with in situ measurements over the VOCALS region.

The retrieval uncertainty of MODIS is never mentioned in this study. MODIS retrieval is not perfect. It is actually subjects to all kinds of uncertainties (see http://modis-atmos.gsfc.nasa.gov/_docs/atbd_mod05.pdf). A 1$\sim$2μm difference between MODIS and in situ measurement may be comparable, or even smaller, in comparison with MODIS uncertainty. In such case, it is meaningless to chase after the small difference. The MODIS effective radius retrieval uncertainty can be found in operational MODIS MOD06_L2 product (sds name "Cloud_Effective_Radius_Uncertainty"). This product provides an estimated relative uncertainty (i.e., in percent unit) for effective radius retrieval. this product may help clarify whether the difference between MODIS and in situ measurement is significant or not, in comparison with intrinsic uncertainty in MODIS retrieval.

The cases selected for this study need to be better described. The description of these cases might be the largest contribution of this paper to the cloud remote sensing community. At very least, the location, time and instrument used for these should be tabulated.

The discussion on the origin of MODIS bias seems too simple and not convincing. The authors attribute the MODIS bias to cloud vertical structure and cloud thickness. But, in Fig. 6b the MODIS and in situ Re difference seems not correlated with cloud thickness. The adjustment of in situ Re by a factor of 6/5 in Fig. 5 does not make the comparison much better. More importantly, the authors did not discuss and exclude other possibilities, such as 3-D radiative effects, sub-pixel variability, and temporal and spatial mismatch between MODIS and in situ measurements. Why are they not important?

MODIS provides not only effective radius retrieval based on the 2.1μm band, but also two other independent retrieval based on 1.6μm and 3.7μm. These bands have different penetration depth into cloud (Platnick 2000 JGR). So if the authors' hypothesis is correct, that cloud vertical structure due to adiabatic growth is the origin of MODIS bias, the authors shall find Re(3.7μm)> Re(2.1μm)> Re(1.6μm). This may be a way to make the argument stronger.

The in situ measurements are compared with 5km and 25km area-averaged MODIS retrieval. Better agreement is found with the 25km averaged MODIS retrieval. But why? What are the implications? This is somewhat counter-intuitive and worth explanation. Instead of focusing on mean value comparison, I think it might be interesting to compare the in situ measurements with the statistics of the MODIS retrievals over 5km or 25km area.

Specific comments: Fig 2. needs to be better explained. What do "outbound" and "inbound" mean in the figure legend? Are these terms necessary?

The impacts of cloud vertical structure on MODIS effective radius retrievals have been discussed in several previous studies (e.g., Nakajima and King 1990 JAS, Platnick 2000 JGR). It is a well-known issue. Therefore, the section 4 is not really necessary.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 1419, 2012.