General comments to reviewers:

The authors would like to sincerely thanks the two anonymous reviewers for the time they donated to review this paper. All of the specific comments are being addressed in the following. However we would like to start by clarifying one of the main concerns that both reviewers have raised regarding the exact scope of the paper. This scope wasn't sufficiently stated nor explained and we agree with the reviewers that this was much needed to help improve the paper.

We would like to clarify that the current analysis has been purposely focused on the different products provided by POLDER and MODIS because this work was part of a larger exercise to understand and document the uncertainties associated to cloud products obtained from the two instruments [Zeng et al, 2012; Zeng et al, 2013]. A similar analysis applied to the synergistic algorithm and product described in Riedi et al, 2010 would of course be of interest but our focus has been on documenting uncertainties and potential biases of both the MODIS and POLDER products independently of the joint product which can only be obtained for the 5 years of coincident POLDER and MODIS observations. The individual MODIS and POLDER phase products are at the opposite available for the entire duration of their respective mission (more than 15 and 12 years for MODIS/Terra and MODIS/Aqua respectively and 8 years for POLDER3/PARASOL).

Although the current paper provides statistical evidences that the combination of POLDER and MODIS observations can be used to provide improved phase decision, it was correctly identified by the reviewers that the more theoretical analysis provided in Riedi et al (2010) paper already contained convincing elements for such a conclusion.

Therefore, if the statistical analysis provided here confirms the interest of a joint phase retrieval algorithm, the scope of the paper is clearly to inform about the actual strengths uncertainties and biases existing in individual POLDER and MODIS datasets. This is especially important because (i) these individual datasets span over a longer time period than the coincident POLDER/MODIS observation range and (ii) the individual phase decisions made from each sensor impact the subsequent cloud properties statistics obtained from each sensor.

We have now modified the paper throughout to provide a better and more focused statement of its scope and also clarified the conclusion to better reflect the current findings instead of providing lengthy prospective consideration about a merged product which was unnecessary and misleading regarding the actual paper scope. Again thanks to the reviewers for pointing this out clearly.

Answers to specific comments to the second reviewer:

S1. Comparisons with the combined phase algorithm proposed in Riedi et al. (2010) should have been included. (I do not feel that this is an undue request considering the author overlap between this paper and Riedi et al. (2010).)

Please refer to the introduction and joint answer to both reviewers above.

S2. The Introduction section does not make a strong case for the purpose of the

conducted study.
We modified the introduction, please see question C2.

S3. The abstract is written in the style of a conference submission abstract rather a scientific paper abstract. It should be revised to quantitatively summarize the most relevant results.

The abstract has been modified to read as follows:
The A-Train observations provide an unprecedented opportunity for the production of high quality dataset describing cloud properties. We illustrate in this paper the use of one year of coincident POLDER (Polarization and Directionality of the Earth Reflectance), MODIS (MODerate Resolution Imaging Spectroradiometer) and CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarization) observations to establish a reference dataset for the description of cloud top thermodynamic phase at global scale. Through an extensive comparison between POLDER and MODIS cloud top phase products and a further discussion of those products in view of cloud vertical structure and optical properties derived simultaneously from collocated CALIOP active measurements, we identify and quantify potential biases present in the 3 considered dataset. Overall, it is shown that POLDER and MODIS agree on 73% of all cases. Agreement reaches up to 93% when only overcast single layer clouds are being considered. Further, it is shown that differences in phase identification can occur for a number of well-identified reasons which are statistically characterized. Among those, it is established that the sensibility of phase identification algorithm depends on observation geometry, occurrence of thin cirrus in multilayered and single layered cloud systems, supercooled liquid droplets, aerosols load, fractional cloud cover and snow/ice or bright surfaces. POLDER better detects liquid clouds in cloudbow directions, single thin cirrus, supercooled liquid clouds, and liquid clouds over snow/ice or bright surface. However the phase identification of thin cirrus in multilayered cloud systems (especially when observed in cloudbow directions) and that of liquid broken clouds (particularly in presence of aerosols) suffer from systematic biases. MODIS has advantages in detecting phases of cirrus in multilayered cloud systems and broken clouds. However it appears to have lower skills in phase identification for supercooled liquid clouds, single layer thin cirrus and clouds over cold and bright surface. These results illustrate and quantify systematic biases in the POLDER and MODIS cloud phase dataset. They shall be considered carefully and accounted for especially when analyzing other cloud properties available in the individual POLDER and MODIS datasets. Finally, this in depth statistical analysis also contributes to better understand the usefulness and strength of the combined POLDER/MODIS algorithm proposed by Riedi et al (2010).

S4. P8375, L24 The paper states that "the offcial cloud phase products from MODIS use index values representation (1 for ice, 2 for liquid, 3 for mixed)". Please explain what is meant by MODIS mixed-phase in this study. The Collection-5 MODIS VIS/SWIR retrieval (Cloud_Phase_Optical_Properties) does not have a mixedphase category and the Collection-5 MODIS IR retrieval no longer uses the mixedphase category (as of Collection-5). This, in turn, leads to questions about the pixels included in the MODIS mixed categories in Figures 1

and 2, e.g. It's reassuring to see that only very small percentages of pixels fall in to the MODIS "mixed" categories, but it is disconcerting that these pixels were included in the data set with no discussion of what they mean. My only assumption is that they are associated with the colocation process, but I have no way of knowing because so few details were presented. It is also strange that they occur so much more frequently over snow.

The reviewer is correct that the mixed phase category we are using is related to the aggregation/colocation process. When MODIS data are aggregated over a given POLDER, we establish a fraction of liquid and ice (as observed by MODIS) within a given POLDER pixel. If liquid (resp. ice) pixels number is twice that of ice (resp. liquid) number, pixel will be labeled as predominantly liquid (resp. ice); in all other cases pixels are labeled as mixed phase. Note that POLDER does have on the contrary a mixed phase class.

Regarding the interpretation of mixed phase, there are certainly too many parameters for describing what a mixed phase cloud could be depending on whether we assume vertical variation of phase (in a single cloud or multilayer) or if liquid and ice are coexisting within a given cloud layer. Generally the passive sensors have poor skills in identifying real "mixed" phase and the mixed phase classification usually results from having not enough clear signals to decide between ice and liquid. Eventually, the combination of more information can provide some skills in identification of multi-layer mixed phase but it is unlikely that single POLDER or MODIS algorithm can unambiguously identify real mixed-phase clouds.

Finally, it seems the reviewer is well aware of the internal details of MODIS product so the authors have checked the comments regarding the use of a mixed phase category in Collection 5 IR algorithm. We of course don't have access to the exact version of the processing code used for C5 nor do we know what was fully intended for C5 IR phase algorithm but looking at several example of the cloud phase infrared product obtained from collection 5 MYD06_L2, the authors were able to easily find that the "Mixed-Phase" and "Unknown/Uncertain" categories were still being used.

Regardless of this later point, the number of mixed situations is indeed relatively small, whether it corresponds to "retrieved" mixed phase or to "mixed situation" arising from the colocation process.

S5. It is not always clear which MODIS phase product is being used in various parts of the study. P8377, L17 states "If not otherwise specified, cloud phase used for the comparison with POLDER is the latter one as it corresponds to the daytime algorithm and benefits from the combination of both solar and thermal infrared measurements." The cases where the MODIS IR algorithm are used should be made explicitly clear and, if possible, the results from the SWIR algorithm should also be included.

As explained in the introduction, these analyses were part of a larger effort to understand and document differences and similarities in cloud properties derived from POLDER and MODIS. Because MODIS is using output from the "combined" phase algorithm (not the IR one) to retrieve subsequent cloud optical properties, this combined product has been studied in particular. Only in Fig 8 we used MODIS IR phase. This is because we tried to figure out whether the angular biases for the MODIS algorithm were coming from the

SWIR test or the IR test involved in the combined algorithm.
We modified the phrase at P8377, L17. We state as following so that readers are more clear about what kind of products we have been used in the paper. Thanks for this careful reviewing.
"Except in Figure 8 we also use the MODIS IR phase, cloud phase used for the comparison with POLDER is the latter one as it corresponds to the daytime algorithm and benefits from the combination of both solar and thermal infrared measurements"

S6. The Conclusions section discusses the effects of combining MODIS and POLDER, yet such a combination was not done in this paper. (A comparison is not the same as a combination and the conclusions section should focus more on the results and their implications.)
Agree. This is now clarified in the conclusions.

S7. Technical editing for English language readability is necessary and goes beyond what I am willing to do as a reviewer. Therefore I have not included typos and other issues in the Technical Comments that follow
We apologize for the poor English language and will make sure to have the paper carefully edited before a revised version is submitted.

3 Technical Comments

C1. P8373, L25 states "The combination of different methods to improve discrimination capabilities is increasingly used for cloud phase retrieval from satellite observations." Yet several of the methods listed do not combine retrieval methods. Please revise.
Sentence was changed to: "Several methods are currently available for discriminating cloud phase from satellite observations relying on significant differences between physical and optical properties of ice and liquid particles".

C2. P8374, L23 states "Past studies of cloud phase from sensors of the A-Train (e.g. POLDER, MODIS, CALIOP or AIRS) have mainly focused on individual case analysis or radiative transfer simulation (Riedi et al., 2010; Chylek et al., 2006; Cho et al., 2009; Kahn et al., 2011) and had not concerned the global long-term assessment of cloud phase using both passive and active sensors in this A-Train constellation." I feel that this is somewhat of a mischaracterization of Riedi et al., 2010; Cho et al., 2009; and Kahn et al., 2011. I recommend revising the quoted statement to better represent the actual findings of the cited papers and then provide more appropriate motivation for the conducted study.
We modified the phrase from P8374, L23 to P8375, L1: "Different studies based on observations from sensors of the A-Train (e.g. POLDER, MODIS, CALIOP or AIRS) have previously focused on providing a better understanding of cloud phase retrieval uncertainties either through theoretical radiative transfer sensitivity analysis (Riedi et al, 2010; Kahn et al, 2011), through cases study comparison between two techniques (Chylek et al, 2006), or based on more extensive assessment against CALIOP observation (Cho et al, 2009). In this paper, we statistically assessed cloud phase products derived from two passive sensors (POLDER and MODIS) at global scale and for an extended

period of time. Comparison are made first between the POLDER and MODIS datasets at global scale and results are further analyzed in view of cloud vertical structure and optical properties derived simultaneously from collocated CALIOP active measurements. Compared to previous studies, our analysis provides the first large-scale comparison between two different cloud phase datasets obtained from different techniques and passive measurements. Both the extended period of analysis and the global coverage permitted by POLDER and MODIS allow to exhibit more representatively than previous studies the potential issues and virtues of investigated datasets. The use of collocated CALIOP measurements finally allows to understand how the horizontal and vertical structures of clouds impact and potentially bias cloud phase retrieval from passive sensors".

C3. P8375, L15 Please explicitly state the time periods included in the study. Regarding the POLDER/MODIS dataset, the text only says that all Aqua/MODIS collection 5 level 2 cloud products and PARASOL/POLDER collection 2 level 2 cloud products are collocated.

This was initially indicated at P8376 L11-12. We now indicate the time period upfront at the beginning of this section.

C4. P8376, L1 "In other situations where both liquid and ice are present within a POLDER superpixel, either liquid or ice dominated phase, or mixed phase is labeled depending on the number of liquid and ice pixels." Please provide details explaining when the superpixel will be assigned each case.

Please also refer to comment above. We added "For example, if the liquid (or ice) pixels number is twice of the ice (or liquid) one, liquid (or ice) dominated phase will be labeled; the rest is mixed phase "

C5. P8375, L16 Please provide more details regarding the collocation of the MODIS and POLDER products. In addition, please define what is meant by a pixel in the context of this work.

Please see P8375 L19-21. The combined pixel is corresponding to POLDER superpixel that is 20´20km2. We add "(20´20km2)" to L21 after "POLDER superpixel" Also more details are available in Zeng et al, (2011) which is indicated in the paper.

C6. P8378, Section 2.3 Please specify exactly which CALIOP product is used in the analysis.

We add a statement at the end of this section: "In this study, the version 2 level 2 CALIOP data are used".

C7. P8382, Section 3.1 The comparison focuses on cloudy, overcast, broken, and multilayered scenes, yet overcast and broken are never explicitly defined in the context of the study. The use of the MODIS overlapping cloud flag is also problematic because the collocation process is not described in enough detail and it is not clear how a common pixel is defined.

At P8382 from L10 to L14, we explained overcast (or broken) means overcast (or broken) as detected by both sensors. Overcast refers to pixels (POLDER resolution) for which cloud fraction has been determined to be 100%. At P8375 in L19-21 we explained POLDER cloud products are directly extracted from POLDER official data and MODIS cloud products are averaged into the POLDER super-pixel. The same procedure is used for multilayer flag, which is an average value of official data. This is possible because the multilayer flag value somehow corresponds to different probability of having a multilayer situation. So even though the exact meaning and coding is not preserved, it remains possible to differentiate super-pixels for which no indication of multilayer situation has been detected by MODIS.

C8. P8387, L4 states "In cases where POLDER and MODIS have inconsistent decisions, CALIOP tends to agree with POLDER more often." I do not feel that Fig. 3 supports this assertion except for the POL (liq)-MODIS (ice) case.

In Picture 3 and 4, please see POL(liq)-MOD(ice), POL(ice)-MOD(mix) POL(liq)-MOD(mix). Considering the number of samples in each category we still feel that CALIOP tend to agree better with POLDER. This is also visible from figure 5 to 7, again taking into account relative weight of each category compared to the total number of samples.

C9. P8387, L14 states "provides a global qualitative understanding of each of the 9 classes obtained when merging POLDER and MODIS products." Since the POLDER and MODIS products have not been merged, this statement does not mean anything. (Collocating two products is not the same as merging products.)

Modified "merging POLDER and MODIS products" -> "POLDER and MODIS products are jointly analyzed".

C10. P8394, Section 5.3 and Fig. 10 Inclusion of "Using IR brightness temperature or brightness temperature differences provides little information to discriminate cloud phase due to the small contrast between supercooled and ice water." implies that Fig. 10 shows the MODIS IR phase results. If this is the case, please state it explicitly and include the MODIS SWIR phase results in the figure and discussion. If it is not the case, please remove the quoted sentence.

This refers to the combined phase product not the IR phase as mentioned in S5. As the combined phase includes IR information to distinguish cloud phase, this part of information could bias cloud phase determination.

We modified it to make the statement more clear:

" Parts of the algorithm that rely on IR brightness temperature or brightness temperature differences provide limited information to discriminate cloud phase in case of supercooled water droplets due to the small contrast with ice water. MODIS phase products can be biased in these cases"

C11. P8394, Section 5.3 and Fig. 10. It should be mentioned in the text that the CALIOP phase algorithm does make use of cloud temperature in its phase determination (Hu et al. 2009).

P8387 L23-26, we have already stated, "It primarily uses layer integrated depolarization of the backscattered light and cloud top temperature (derived from measured altitude and

meteorological temperature profile) to classify cloud phase as ice or liquid water".
We could repeat this information here to make it perfectly clear that the CALIOP phase determination is not fully independent of temperature.

C12. Section 5.4 I do not feel that the section discussing aerosols is quantitative enough to be included in this paper. In addition, the statement in the Conclusion on P8397, L13 "From this study we have seen that POLDER can erroneously detect broken clouds scenes and aerosols overlaying water clouds as mixed or ice phase" is not justified by the study. There is a CALIOP aerosol product that could form the basis for a more detailed study.
Several studies and papers by Waquet et al (2009, 2013a, 2013b) provide clear evidence of this and although we do not quantitatively estimate the impact of aerosols on the observed differences, we feel that we should at least briefly indicate this known potential issue.
In section 5.4, we propose to refer to the studies by Waquet et al (2009) and Waquet et al (2013) who discussed this impact of aerosol above clouds on phase detection. And also the statement in the conclusion will be modified to refer to these studies.

C13. Section 5.6 Is a snow mask used in this study? If so, it should be stated.
No snow mask was used here. Section 5.6 only discussed this issue in view of results for areas which are known to be permanently or largely snow covered.

C14. Figure 1 The numbers and some of the light colored fonts in the text to the le of the pie charts is difficult to read on a screen without significant magnification. Perhaps this would not be difficult in a print-out, but so many people read papers on computer screens and tablet devices that this is an issue.
We changed the figure to make it easier to read in the revised version.

C15. Figure 3's caption states that it shows opaque clouds, as does Figure 4's caption. Yet only Figure 4 has the text "Opaque Clouds" above the figures.
Agreed: figure 4 will be corrected and the text "Opaque clouds" removed from the graphic.

C16. Figures 5-7: The information in these figures could be more easily conveyed in tables.
Agreed: Also the other reviewer has suggested merging these numbers directly into Figure 3-4. Figure 5-7 will be removed and numbers provided directly in figure 3-4 if possible.

References

We add:"Cho, H.-M., P. Yang, G. W. Kattawar, S. L. Nasiri, Y. Hu, P. Minnis, C. Trepte, and D. M. Winker, 2008: Depolarization ratio and attenuated backscatter for nine cloud types: analyses based on collocated CALIPSO lidar and MODIS measurements. Optics Express, 16 (6), 3931–3948"

We add: Waquet, F., Cornet, C., Deuzé, J.-L., Dubovik, O., Ducos, F., Goloub, P., Herman, M., Lapyonok, T., Labonnote, L. C., Riedi, J., Tanré, D., Thieuleux, F., and Vanbauce, C., Retrieval of aerosol microphysical and optical properties above liquid clouds from POLDER/PARASOL polarization measurements, Atmos. Meas. Tech., 6, 991-1016, doi:10.5194/amt-6-991-2013, 2013.

Figure modified:

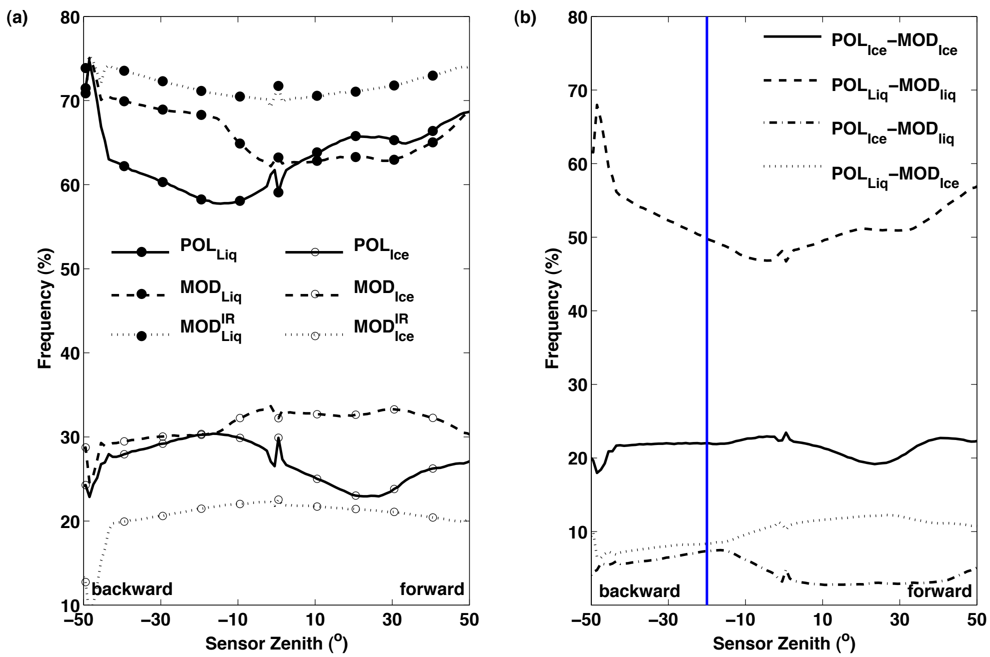


Fig 8.

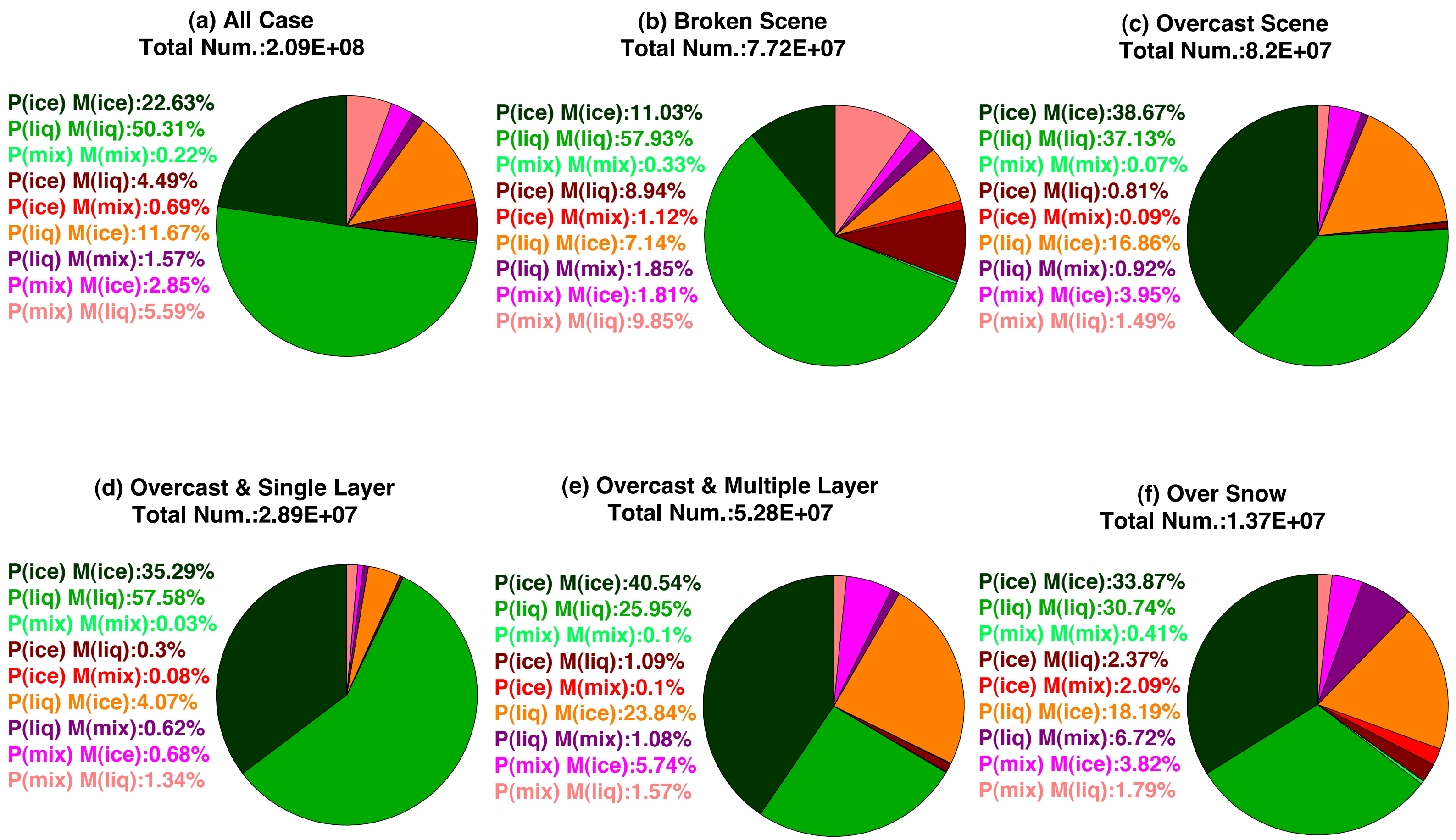
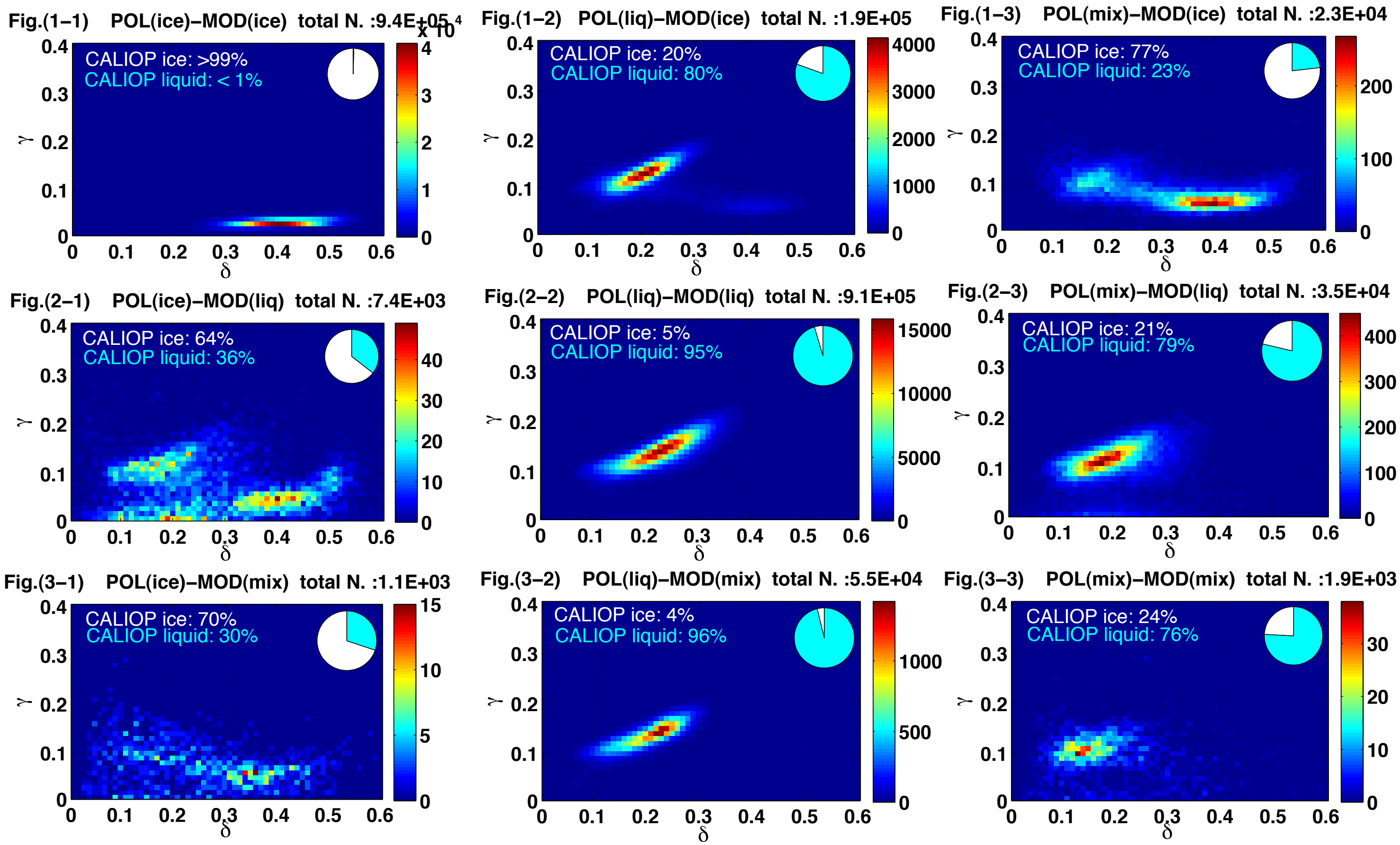
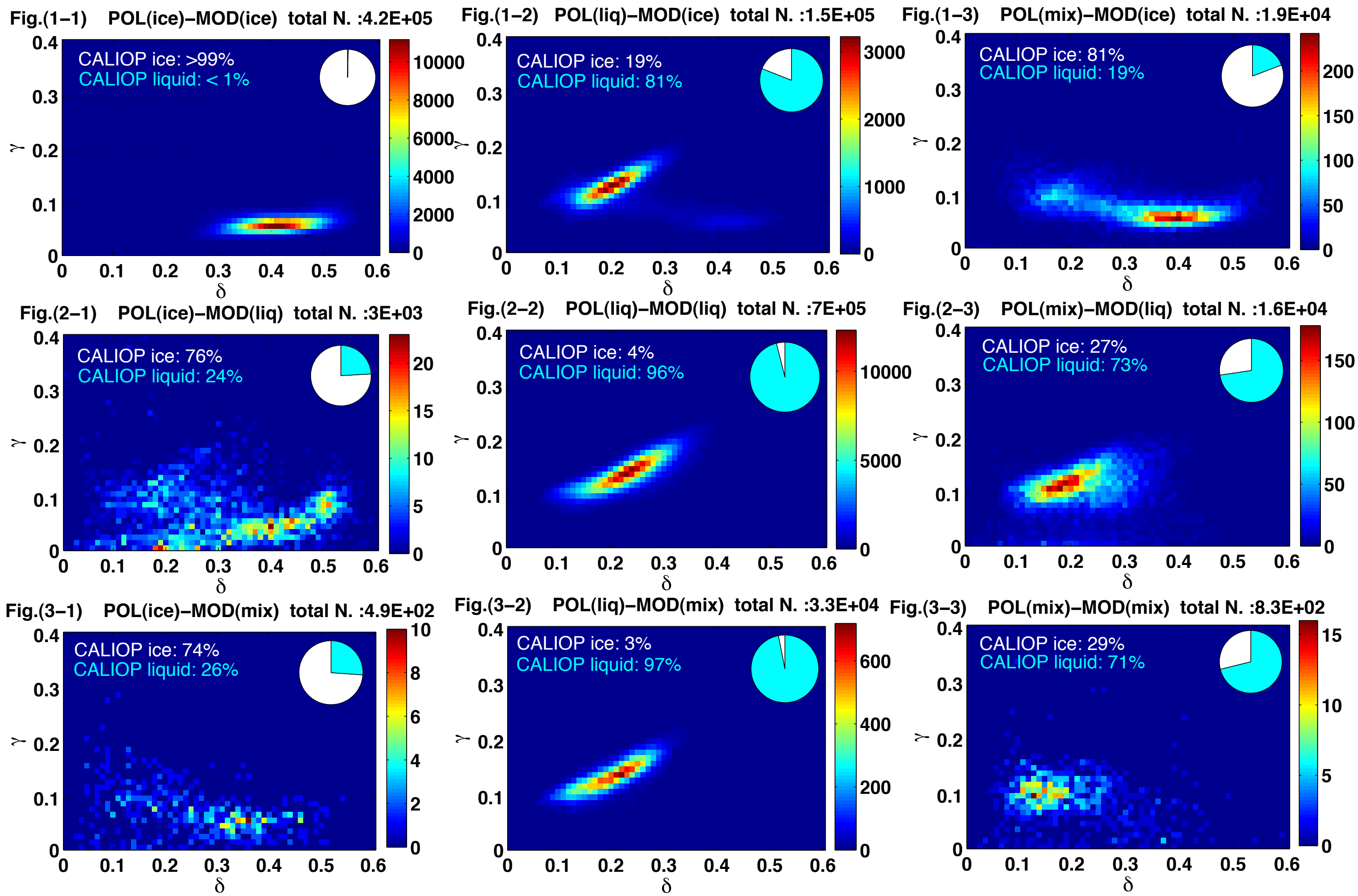

(a) All Case
Total Num.:2.09E+08
P(ice) M(ice):22.63%
P(liq) M(liq):50.31%
P(mix) M(mix):0.22%
P(ice) M(liq):4.49%
P(ice) M(mix):0.69%
P(liq) M(ice):11.67%
P(liq) M(mix):1.57%
P(mix) M(ice):2.85%
P(mix) M(liq):5.59%
(b) Broken Scene
Total Num.:7.72E+07
P(ice) M(ice):11.03%
P(liq) M(liq):57.93%
P(mix) M(mix):0.33%
P(ice) M(liq):8.94%
P(ice) M(mix):1.12%
P(liq) M(ice):7.14%
P(liq) M(mix):1.85%
P(mix) M(ice):1.81%
P(mix) M(liq):9.85%
(c) Overcast Scene
Total Num.:8.2E+07
P(ice) M(ice):38.67%
P(liq) M(liq):37.13%
P(mix) M(mix):0.07%
P(ice) M(liq):0.81%
P(ice) M(mix):0.09%
P(liq) M(ice):16.86%
P(liq) M(mix):0.92%
P(mix) M(ice):3.95%
P(mix) M(liq):1.49%
(d) Overcast & Single Layer
Total Num.:2.89E+07
P(ice) M(ice):35.29%
P(liq) M(liq):57.58%
P(mix) M(mix):0.03%
P(ice) M(liq):0.3%
P(ice) M(mix):0.08%
P(liq) M(ice):4.07%
P(liq) M(mix):0.62%
P(mix) M(ice):0.68%
P(mix) M(liq):1.34%
(e) Overcast & Multiple Layer
Total Num.:5.28E+07
P(ice) M(ice):40.54%
P(liq) M(liq):25.95%
P(mix) M(mix):0.1%
P(ice) M(liq):1.09%
P(ice) M(mix):0.1%
P(liq) M(ice):23.84%
P(liq) M(mix):1.08%
P(mix) M(ice):5.74%
P(mix) M(liq):1.57%
(f) Over Snow
Total Num.:1.37E+07
P(ice) M(ice):33.87%
P(liq) M(liq):30.74%
P(mix) M(mix):0.41%
P(ice) M(liq):2.37%
P(ice) M(mix):2.09%
P(liq) M(ice):18.19%
P(liq) M(mix):6.72%
P(mix) M(ice):3.82%
P(mix) M(liq):1.79%

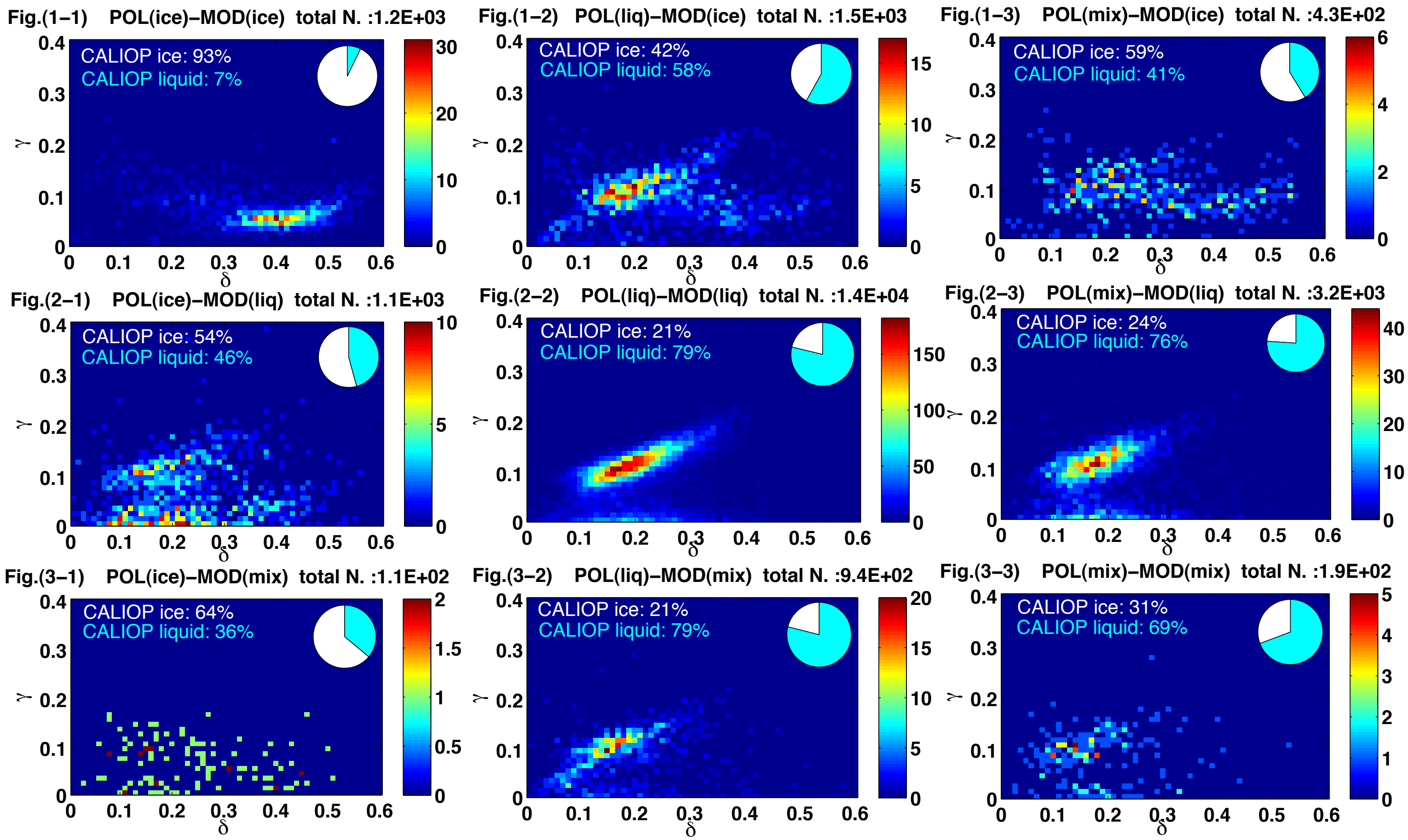
Fig 1.



Combine Fig 3. & 5 for all clouds



Combine Fig 4 & 6 for overcast clouds



For broken clouds