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 first reviewer:

Vertical distribution of retrieved information:

As stated by the authors the three different sensors are sensitive to different parts of the clouds due to the physical basis of the method. POLDER and CALIOP rely on information by single scattering which is limited to the cloud top. It is easy to estimate by Lambert-Beers Law that 99% of the radiation that is scattered only once within the cloud can not have reached cloud optical depth larger 2.3 (CALIOP geometry). For POLDER considering the solar zenith angle this is even less. However the MODIS

method is based on absorption and multiple scattering. Thus the SWIR/VIS channels obtain information also from lower cloud parts which can be quantified by vertical weighting functions (Platnick, 2000; Ehrlich et al., 2009). These weighting functions differ for different wavelength, clouds and geometries but in general show that also lower cloud parts are sampled. MODIS IR algorithm will again have a different vertical weighting function. This means that for the interpretation of cloud phase products the vertical weighting has to be considered. Each sensor sees a different part of the cloud and disagreements in phase retrieval might result just from clouds with vertically separated phases. The discussion about these different views of the sensors is to short in the manuscript. Especially multi-layer and mix-phase clouds might be affected. In this regard the manuscript should be improved. I suggest to add at least a discussion on the problem. I'm sure some of the inconsistencies can be explained by considering the vertical weighting. Splitting up the MODIS retrieval into the SWIR/VIS classification and the IR classification might help too. MODIS IR, POLDER and CALIOP should be sensitive to the same cloud region, only the very cloud top.

This is indeed valuable information that we didn't discuss clearly enough in the initial version of paper and a short discussion of the different weighting function would be useful and appropriate. In fact the paper by Riedi et al (2010) provides such a discussion and we will refer to it for further details about this question. In particular the sensitivity of the three main metrics being used by MODIS and POLDER (IR or VIS/SWIR bispectral for MODIS, polarization for POLDER) had been analyzed for scenarios of an ice cloud overlaying a water cloud which represent a predominant situation when POLDER and MODIS disagree on phase. The reviewer is correct in pointing out the fact that IR method and CALIOP will tend to be sensitive to the very top layer (especially for high cold clouds) but in case of multi-layer situations, POLDER can also see lower liquid clouds "through" the thin cirrus because of the highly polarized rainbow feature.

Regardless, the reviewer is correct that this discussion was not developed enough and we will also refer more clearly to the theoretical sensitivity study available in Riedi et al (2010) regarding this question.

In their conclusion the authors refer to an existing synergetic POLDER/MODIS phase algorithm (Riedi et al., 2010). When beginning to read the manuscript my understanding was that one motivation is to look at problems in the individual retrievals which may help to develop combined algorithms. Now there is already a combined algorithm which certainly deals with all the problems described in this manuscript. I do not understand why this algorithm was not applied to the dataset investigated by the authors. Riedi et al. (2010) did already investigate the weekness and strength of MODIS and POLDER. Not on a global scale but it was used to develop a more confident retrieval algorithm. This substantial progress in cloud phase classification should not be neglected here. Using POLDER and MODIS only separately is not the current state of the art. I may cite from the manuscript (conclusions):"As a synergistic phase algorithm has been created from the PM Dataset (Riedi et al., 2010), more investigations are needed for this new phase product, which will help to quantify the value of the combined POLDER/MODIS retrieval techniques." There is no better place than this manuscript to do that! You can simply

add the combined retrieval to your analysis and demonstrate the improvements compared to the single algorithms.

The reviewer is correct that Riedi et al (2010) already provided some insight into the strengths and weaknesses of the POLDER and MODIS retrieval techniques. In practice, the joint algorithm has been developed from early validation results of POLDER and MODIS products, combined with experimental and theoretical studies that had been done (for the most part) over the course of developing both MODIS and POLDER individual retrieval algorithms. At that time, no extensive validation of the joint algorithm had been performed because efforts were focused on understanding the differences and similarities between POLDER and MODIS cloud products in general (not only phase). This is the scope of the current paper as we have tried to express more clearly now.

Finally the validation of the synergistic algorithm would eventually require to understand and statistically quantify the skills of the various metrics being used. This current paper therefore provides some ground statistics to perform an evaluation of the phase product obtained from the synergistic algorithm which we definitely will evaluate. But as mentioned in the general comments, this is not the main scope of the present paper.

P8379, 1-4: This was already known.

Maybe we misunderstood the reviewer comment but we would like to keep it because this is basic information which helps to understand for someone who isn't familiar with the CALIOP phase.

P8385, 4-10: Much to general. The reader does not need another introduction. Further, most of it was already written in the section before.

We deleted the sentence "It appears clearly from the above studies that the 9 combined phase classes are not randomly distributed and are most likely associated with particular environmental conditions which need to be further studied and discussed."

P8387, 8-11: Sounds a little self-praising, especially as this statement was repeated several times in the text. Can be moved into the conclusion. Further this synergetic algorithm already exists.

We delete "and demonstrate the high quality of the joint dataset calling for a synergistic use of both products when trying to build a global statistics of cloud thermodynamic phase" here.

P8387, 13-15: That was already motivated and has not to be repeated here.

We still keep this because it allows the readers to clearly see the difference between section 4.2 and 4.1. It connects section 4.2 and 4.1 and makes the next introduction easier to understand.

P8393, 25-28: Please remove these general conclusions in this section. The second sentence is repeated and irrelevant, as the synergetic algorithm already exists.

We delete "This confirms that the sensitivity to thin cirrus is different between POLDER and MODIS. This first quantitative evaluation of their respective sensitivity in case of multilayered clouds provides useful information again for using the two datasets in a synergistic way"

P8394, 18-20: Move to conclusions. The word "again" already shows that this comment was already given in the manuscript.
We delete "This results clearly demonstrates once again the strong advantage of POLDER for establishing cloud phase statistics which are unbiased with respect to cloud temperature" here

P8395, 13-15: One example of a summary, which can be deleted. What is summarized?
We delete "As a summary, those aerosols with non-spherical shapes may cause issues in detecting the phase of low clouds when relying solely on the polarization measurement from POLDER" here.

Conclusion:
This is not a conclusion. It is a short summary and an outlook. First the intention of the study was repeated, "This study dedicated....", "The study....allow to provide...", which is quite general but ok. What follows is a summary of the results. This summary is way too short and too general. There are no real conclusions. What is missing are answers to questions like: What are the main news provided in the paper. Which sensor has to be used in what cases? What are the most difficult cases and how can they be solved? Give the main numbers which are the result of the study and should be keept in mind by the reader. The last part is a very enthusiastic and optimistic outlook but still no conclusion."...provide invaluable source of information..." sounds again a little self-praising especially as the benefit for studies on phase transition, etc. was not shown in the manuscript and is only speculation. Similar the phrase "...it is anticipated..." indicates that this is an outlook but not a conclusion. I don't want you to remove this outlook but the major part of the conclusion should be concluding remarks on the presented study and not speculations.

We have modified the conclusion which now reads as follows:
Cloud phase is a critically important cloud parameter for cloud observation and modeling. Whether the clouds are ice or liquid is associated to the cloud formation and development processes and any changes in cloud phase could greatly impact the cloud radiative properties and feedback to the climate system. This paper provides a statistical study of this key parameter from collocated observations of three sensors of the A-Train constellation. In view of the advantages and limitations of different phase retrieval methods used by POLDER, MODIS and CALIOP, we compared the phase products between the passive sensors, interpreted and validated the combination of phases derived from passive sensors against the one derived from the active sensor CALIOP. The validation and combination of these 3 different cloud phase products allow to provide more confident cloud phase information and gain more insight in case of ambiguous situations. This study dedicated to comparison and validation of different cloud phase products provides a global survey of cloud phase, allowing to establish distributions of the consistent (highly confident) and ambiguous cloud phase situations determined from POLDER and MODIS.
The statistical analysis provides a first quantitative understanding of cloud phase

distribution at global scale, together with an evaluation of the main uncertainties associated with the products. The angular biases in cloud phase detection existing in MODIS and POLDER products were also investigated. Over all cloudy scenes, the total frequency of agreement on phase between POLDER and MODIS reaches about 73% of all pixels that is not bad satisfied. In overcast cloudy cases agreements on phase increases to 77% while in broken cloudy cases, they decrease to 69%. The best agreements on phase appear in single cloudy system (93%) and worst over snow-covered surfaces (64%). The disagreements between the two sensors correlate to special atmospheric evens corresponding to different regions. For example, the clouds labeled as ice by POLDER but liquid by MODIS occur around Africa and China; the clouds labeled as liquid by POLDER but ice by MODIS are vast in the ITCZ; the clouds labeled as mixed by MODIS regardless of POLDER decision, often occur over snow; the clouds labeled as mixed by POLDER and liquid by MODIS appear more frequently in regions where the broken clouds are predominant and the clouds labeled as mixed by POLDER and ice by MODIS occur in Storm Tracks and the ITCZ.

The comparison of POLDER and MODIS phase products against CALIOP demonstrated the high confidence that can be achieved in phase detection when both passive sensors agree. CALIOP agrees for more than 95% of the confident phase cases detected by both passive sensors while for inconsistent and less confident phases, CALIOP partially agrees with either POLDER or MODIS, but preferentially with POLDER certainly because of both instruments extract phase information from polarization characteristics of clouds.

In addition, inconsistent phase decision between the two passive techniques can inform more atmospheric information and be related to the presence of broken clouds, thin cirrus, heavy aerosols, snow, desert, supercooled water or multilayered clouds. From our discussion we have seen that both POLDER and MODIS cloud phases have angular identification preference and are sensitive to different atmospheric conditions. POLDER can erroneously detect broken clouds scenes and aerosols overlaying water clouds as mixed or ice phase. For thin cirrus over liquid clouds, POLDER phase is also biased because of the strong polarization from the below liquid clouds. However it can correctly identify cloud phase in case of single layered thin cirrus, water clouds over snow and the supercooled water clouds. Compared to POLDER, MODIS detects better the thin cirrus above water clouds and demonstrates better skills in identifying correctly the phase of broken clouds. But it has problem to detect the phase of single layered thin cirrus and suppercooled liquid clouds. Each sensing has its own advantage and weakness, Combination of more information from different sensors make it possible to detect confident phase even in a complicated atmospheric condition.

This analysis and the joint POLDER/MODIS dataset that has been created open numerous perspectives for a better description of cloud thermodynamic phase at global scale. As a synergistic phase algorithm has been created from the PM Dataset (Riedi et al., 2010), more investigations are needed for this new phase product, which will help to quantify the value of the combined POLDER/MODIS retrieval techniques. This high confidence dataset could also be used to assess other cloud phase products derived from different instruments than those used in this study. The joint products used in our analysis also provide an invaluable source of information for studying cloud processes such as phase transition or the impact of aerosols on nucleation and glaciations mechanisms.

Finally, it is anticipated that the combination of POLDER and MODIS illustrated here will prefigure what can be achieved from the combination of the 3MI and METIMAGE sensors on EPS-SG (EUMETSAT Polar System – Second Generation). This will hopefully foster the use of such cloud products for the evaluation of parameterizations in weather forecast and climate models, and the development of assimilation techniques for microphysical properties of clouds.

1.3 Minor comments

P8373, 22: authors name three aspects to distinguish cloud phase. I suggest to add the particle shape as an additional aspect. In the manuscript this is mixed with the size but should be a stand-alone parameter. The crystal shape affects the scattering phase function and is used e.g. by MISR for phase discrimination (McFarlane al., 2005; McFarlane and Marchand, 2008; Ehrlich et al., 2008)

We modified it as following: "The distinctions between ice and liquid water clouds mainly lie in four aspects. First, liquid cloud droplets are usually warmer than ice crystals. It is hard for the supercooled droplets to remain in metastable state when the ambient temperature decreases down to −40 _C and also ice crystals are no longer existing above the melting temperature (Pruppacher and Klett, 1997). Secondly, the typical liquid droplets are considered to have spherical shape and non-spherical particles mainly characterize the ice crystals (McFarlane al., 2005; McFarlane and Marchand, 2008; Ehrlich et al., 2008). Thirdly, liquid droplets have relatively small effective radii (ranging from 0.5 to 50 μm and typically reff <30 μm) (Hansen, 1971; Paltridge, 1974; Stephens et al., 1978) while ice crystals have relatively large effective radii (with extreme variable sizes: ranging from a few microns to 1000 μm and typically reff >30 μm) (Fu, 1996; Lawson et al., 1998). Forthly, …"

P8376, 3: Please specify for what numbers the decision between ice, liquid or mixed is made in case of super pixels with different sub-pixel. This is essential and may bias the results depending on the decision made here.

As identified by the second reviewer, the mixed phase category we are using is related to the aggregation/collocation 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.

We modified the text to read "For example, 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 "

P8376, 14: Typo: "is a multi-..."

We add "a" between "is" and "multi-polarization…"

P8376, 14: Give number of bands. 443-1020m looks like POLDER is measuring continuously.

We modified the phrase as the following: (9 bands between 443 and 1020 nm)

P8377, 6: The description of the POLDER algorithm is a bit too general. Is there a way to give a compromised version of how thresholds are defined and how they are applied. This would be nice. Otherwise, state explicitly that details are given in Goloub et al. (2000).
We modified it as following:
"Four tests are included in the retrievals: (1) the polarization angular signature shows a remarkable peak (cloud bow) for liquid clouds at around 140°_ of scattering angles; (2) for scattering angles less than about 120°, polarized reflectance signature tends to be positive with a negative slope for ice clouds whereas it increases with scattering angle for liquid clouds; (3) there is a neutral point between 75° and 130° for liquid clouds; (4) the dispersion of linear fit of polarization for scattering angle larger than 140° are small for ice clouds. Depending on the sample of scattering angle, a pixel may be classified as mixed if opposite phase signal appear. (For further details interesting readers can refer to Please see Please see Plate 3 in Goloub et al, 2000)"

P8377, 9: "relatively" is always an expression which alone does mean noting. You mean "higher compared to POLDER" and "wider compared to POLDER".
We delete "relatively", we do mean compared to POLDER, but it is also compared to some of other instruments.

P8377, 12: Typo: "band"
We delete "a… a…"

P8378, 6: Typo? "differences exist" instead of "it exists differences"
We modified it to "differences exist"

P8379, 4: What is the threshold for the thin clouds applied here? Thicker liquid clouds also will give a depolarization signal due to multiple scattering.
There is no threshold being applied here per say. However we estimate that the situation will occur for cirrus optical depth smaller than 1 to 1.5.

P8380, 1: How mixed-phase clouds would be classified from theory? Liquid or ice? In general I don't understand. MODIS provides a mixed-phase classification. But is neither here nor in Section 2.2.1. stated what thresholds are applied to identify mixed-phase conditions.
There are 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. Defining theoretical thresholds for mixed phase identification is therefore extremely difficult.

For the MODIS IR algorithm however, you can find in Menzel et al. (2006) that mixed phase is determined when 238K<T11<268K and -0.25K<T8.5-T11<0.5K but again this corresponds more certainly to situations where not enough information is available to make a clear distinction between liquid and ice.

P8381, 7: For cloud optical thickness here COT is used as symbol. Before* t *was already introduced as symbol for optical thickness. I would suggest to stick to one symbol, preferable* t*.

We modified in the text: "For t>2 to 3, ice will be detected whereas similar situation will be flagged as liquid if cirrus t<1. For 1<t<2, the underlying liquid feature could pass though the cirrus and the mixed or undetermined flag may be labeled"

P8381, 15: To give a better overview about the three sensors at least wavelength, pixel size, physical basis (single scattering, absorbtion), depth of vertical weighting for the penetration into the cloud, general restrictions.

We propose to add the following table as a summary:

Instruments	POLDER	MODIS (SWIR/VIS)	MODIS (Bi-spectral IR)	CALIOP
Physical basis	Angular polarization	Absorption differences	Absorption differences	Depolarization and backscatter
Wavelength	865nm	0.645mm & 1.64/2.13mm	8.5mm & 11mm	532nm
Resolution	20´20 km^2	5´5 km^2	5´5 km^2	5´5 km^2
Advantages	(1) Insensitive to particle size (2) Insensitive to cloud top or surface temperature (3) Insensitive to atmospheric profiles	(1) Insensitive to cloud top temperature (2) Insensitive to atmospheric profiles	(1) Observations independent of solar light	(1) Sensitive to thin cirrus
Limitations	(1) Depends on the sampling of available scattering angle (2) Difficult for very thin clouds, broken clouds, cloud edges and aerosols over liquid clouds	(1) Depends on particle sizes (2) Difficult for very thin clouds (3) Biased by the spectral difference of the surface albedo	(1) Depends on particle sizes (2) Difficult for very thin clouds (3) Depends on the ground or cloud top temperature (4) Depends on atmospheric	(2) Insensitive to low liquid clouds

			profiles (both temperature and water vapor profiles)	

P8381, 20: Here the data is divided into ice, liquid and mixed-phase. But how mixed is defined in all three individual retrievals? The general description only deals with the separation of liquid and ice. The decisions made for a classification of mixed-clouds has to be add in a revised manuscript as this might be of importance to understand the differences in the three retrieval products. Biases may erase as the single algorithms define mixed-phase clouds for different conditions.

We add mixed phase for POLDER and MODIS in the description of algorithm. For CALIPSO, there is no mixed phase. Please refer to the answers to the questions P8377, 6, P8380 and P8376, 3

P8382, 5: "annual" is somehow misleading. It is only one year that was analyzed. Annual suggest more than one plot or more than one year of data. Better to repeat here the period of data you used in the study.

We modified the phrase as the following:

"…we plotted the global percentages of the 9 classes for different environments in order to see in which conditions POLDER and MODIS tend to present consistent or inconsistent phase determination."

Figure 1: Numbers in this color code are very difficult to read and I think the chart. I suggest to change the plot into a table which presents the 3x3 matrix where only the numbers are given. The fill color of each field may be chosen as color coded related to the numbers.

Can you additionally give the total number of cloud phase for each sensor without combining the two sensors? This would be easy to implement in the suggested table. Then it would be easier to see, which phase dominates or not. E.g. the mixed-mixed-combination seems to be very rare.Is that because the algorithms differ so much or just because there are in general only few casesclassified as mixed-phase?

We changed the figure colors and added a table too.

All Cloudy Scene					***Broken Cloudy Scene***					***Overcast Cloudy Scene***				
%		***MODIS***			***%***		***MODIS***			***%***		***MODIS***		
		Ice	***Liq***	***Mix***			***Ice***	***Liq***	***Mix***			***Ice***	***Liq***	***Mix***
POLDER	***Ice***	***22.63***	***4.49***	***0.69***	***POLDER***	***Ice***	***11.03***	***8.94***	***1.12***	***POLDER***	***Ice***	***38.67***	***0.81***	***0.09***
	Liq	***11.67***	***50.31***	***1.57***		***Liq***	***7.14***	***57.93***	***1.85***		***Liq***	***16.86***	***37.13***	***0.92***

	Mix	*2.85*	*5.59*	*0.22*		*Mix*	*1.81*	*9.85*	*0.33*		*Mix*	*3.95*	*1.49*	*0.07*
Overcast Single Layer					***Overcast Multilayer***					***Snow Covered Surface***				
%		***MODIS***			***%***		***MODIS***			***%***		***MODIS***		
		Ice	***Liq***	***Mix***			***Ice***	***Liq***	***Mix***			***Ice***	***Liq***	***Mix***
POLDER	*Ice*	*35.39*	*0.3*	*0.08*	***POLDER***	*Ice*	*40.54*	*1.09*	*0.1*	***POLDER***	*Ice*	*33.87*	*2.37*	*2.09*
	Liq	*4.07*	*57.87*	*0.62*		*Liq*	*23.84*	*25.95*	*1.08*		*Liq*	*18.19*	*30.74*	*6.72*
	Mix	*0.68*	*1.34*	*0.03*		*Mix*	*5.74*	*1.57*	*0.1*		*Mix*	*3.82*	*1.79*	*0.41*

We also propose to add the table for phase of each sensor.

Probability (%)		**Ice**	**Liquid**	**Mixed**
Cloud_Phase_Optical_Properties	All	35	61	4
	Overcast	60	39	1
	Broken	20	76	4
Cloud_Phase_Infrared	All	22	67	12
	Overcast	45	36	19
	Broken	13	82	5
POLDER	All	28	63	9
	Overcast	40	55	1
	Broken	21	67	12

P8382, 20: Similar to the figure, your numbers do not reveal for which phase the algorithm works best as the numbers are related to the total number of observations. If there are in general more liquid clouds present, then it is not surprising, that liquid clouds also give the largest contribution to the pixels with agreement. What I think is interesting is if there are tendencies that one phase is identified better than another. I would suggest to give the percentage of matching classifications for each individual phase. xx% of all liquid clouds have been identified consistently, xx% of all ice clouds.

We don't fully understand the reviewer point here because for the given figure and numbers involved there is no “truth” for phase (as opposed to later when POLDER and MODIS are compared to CALIOP). We could compute the suggested fraction taking one instrument as a reference and the information would indeed provide useful information. We will include these additional statistics as suggested to provide some insight into which phase tend to be more easily identified consistently by both instrument.

However we will also keep the initial numbers because the purpose is to provide statistics about the fraction of clouds for which phase can be identified with confidence. It is interesting to know for instance that 50% of all clouds are confidently in liquid phase.

P8383, 10: For this single cases of disagreement a discussion is given here but not for the others. Above you refer to Sections 5.4 and 5.5 for a discussion about reasons of the disagreement. This is inconsistent. I would prefer to discuss the results right here or shift all the discussion to section 5.

We don't understand the reviewer comments as both single layered and multi-layered clouds are discussed here. We have tried to improve the phrasing however.

P8383, 19: "satisfactory". Are 75% really satisfying? I wouldn't agree considering that cloud phase is such an important parameter.

The sentence now reads: "From the above, we see that a general agreement on cloud phase detection can be obtained in 75% of the situations which, although not fully satisfactory, can still provide a fairly strong observational constraint to models.

P8385, 13: What means layer-integrated? Which layer is integrated, especial for opaque clouds? CALIOP is not known to be able to penetrate clouds with opt. thickness higher than 3-5. So how do you expect to assess POLDER and MODIS with CALIOP?

Layer-integrated means integrated over the whole layer (Please refer to Hu et al. (2009)). Lidar signal which can penetrate COT <5 is not expected to impact our results as POLDER and MODIS techniques are also mostly sensitive to the top cloud layer: polarization saturates for cloud optical thickness larger than ~2 or 3 and similarly IR signal will primarily arise from the very top of the cloud. Looking at Fig. 7 from Riedi et al (2010), one can also notice that the SWIR/VIS ratio information can remain ambiguous for cloud optical depth smaller than about 2~3. Therefore for the range of cirrus optical depth that can lead to ambiguous signal in case of multilayer cloud (ice over liquid) the lidar signal will be able to provide information. Of course, CALIOP has better skill in detecting thin cirrus and that's why we used it to estimate the sensitivity of POLDER and MODIS phase product to presence of thin cirrus.

Figure 3 and 4: Fig. 3 and 4 differ not much. Why? How many nonopaque clouds were observed? Are they really nonopaque as I can not imagine how CALIOP can penetrate a typical liquid cloud.

Figure 3 is for all clouds and Figure 4 is only for overcast clouds, and their differences are coming from broken clouds (at POLDER pixel scale). The differences are small indeed and will happen for example for the case POLDER(ice)-MODIS(liquid). In this case, broken clouds may bias the liquid to ice because surface signal of polarization is similar to ice clouds. In which case it is not unexpected that POLDER detects ice and MODIS detects liquid.

P8386, 21: How CALIOP defines a mixed-phase cloud? How many cased of mixed-phase did CALIOP observe in general. The low number of mixed-phase cases identified by CALIOP is probably due to the method. As in most cases the liquid fraction is dominating the mixed-phase clouds and thus the radiative transfer. Ice might be located mostly at lower cloud layers due to sedimentation. Lower cloud layers are not seen by CALIOP but by MODIS using SWIR/VIS wavelength.

The CALIOP version 2 data has no mixed phase, which has been introduced in section

2.3.

P8387, 3: Please do not repeat yourself. Why you give here a summary from what you just presented five sentences before? Include your discussion right there!
We modified the sentence: "From this picture we clearly see CALIOP features are very consistent with MODIS and POLDER phase products when those two agree…"

P8387, 24: Do not Fig. 5-7 give the same information as do figures 3 and 4? I would suggest to combine the figures by just adding the numbers of agreement in Figure 3 and 4. Why you are now adding broken clouds? Results for broken clouds should have been consistently shown also in a _ plot similar to figures 3 and 4.
The initial idea was to separate the illustration of information coming from lidar signal (which does not depend on CALIOP phase decision) from the statistical results obtained after CALIOP phase algorithm (which depend on implementation of CALIOP phase detection).
We agree with the reviewer comment however that we could simply add the statistics of Fig 5-7 directly on top of Fig 3 and 4, as long as we clearly identify the difference between raw signal and CALIOP phase decision product. We have modified the figures accordingly and provided also results for broken cloud in a similar figure.

P8387, 24: above you discussed that CALIOP did not show many mixed-phase clouds. Why now this class is totally neglegted? Probably because CALIOP is not able to classify mixedphase clouds at all. Then please revise your statement from above.
CALIOP has no mixed phase at version 2.

P8388, 2-3: This conclusion is not new. It was already shown in Figure 3 and 4. So again I suggest to combine Figures 5-7 with 3-4.
Yes, the conclusion is not new but the CALIOP observations are not the final CALIOP phase products. Figure 3 and 4 qualitatively show the agreement between passive based retrievals and active sensor signal whereas Figure 5-7 quantitatively show how much agreement is observed between the three detection methods. This is different because the lidar-based retrievals do not only depend on the illustrated signal. However as explained above we can indeed merge figure 3-4 and 5-7.

P8389, 12: This was already announced at Page 8385 line 1-2 but not discussed in section 4.
Do you mean "discussed in section 5"? Yes, we did. Cloud structure such as supercooled clouds, the single layered cirrus and cirrus in multilayered systems, which requires the use of CALIPSO for their identification.

P8390, 10: Wouldn't it make sense to use the scattering angle instead of viewing zenith angle? Scattering at cloud top and thus the scattering phase function are related to the scattering angle between the direction of the Sun and the viewing angle.
There is no way to see POLDER phase product against its scattering angle because POLDER uses multi-angular polarization to identify phase, which contains information

from different scattering angle. We had thought about this issue but this picture here is the best way to present bias due to observation geography for both POLDER and MODIS.

P8390, 17-18: This sentence is not needed. The reader knows that already. Please remove.
We delete it.

P8390, 19: Introduce that and why MOIDS IR is now shown explicitly.
From the figure we can clearly see the MODIS IR phase detects more liquid phase in any angle, but POLDER and MODIS combined phase are more comparable. We introduce IR phase here because we want to compare with other two phases, and show the ideal phase should be insensitive to observation geometry. Because the IR signal has less angular variability than VIS/SWIR observations, we use the IR phase to illustrate what can be expected from a technique that is supposed to have little angular biases. In addition it also help illustrates that the angular identification preference of MODIS combined phase comes from the VIS/SWIR test and not from the IR tests.
We added some introduction here: "MODIS IR phase are also included in the figure to help us understand angular geometry biases of MODIS combined phase."

P8390, 25: Give numbers for the magnitude of increase /decrease in the text.
We added: "(less than 5%)"

P8390, 28: "optical properties"? You mean SWIR/VIS to be consistent.
No, it's MODIS combined phase (Cloud Phase Optical Properties). We modified here: "MODIS combined phase"

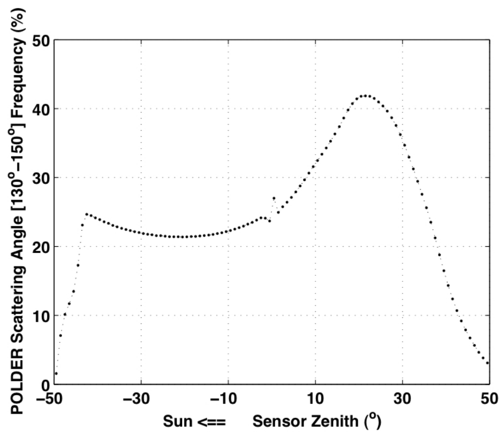
P8391, 2: Again, give numbers in the text.
We added: "(less than 5%)"

P8391, 13: It is not only the forward scattering in combination with multiple scattering. Due to the particles scattering phase function clouds do have a certain BRDF, which looks very similar to the particle phase function (Ehrlich et al., 2012). As the phase function is not constant over the scattering angles observed here, also the BRDF varies. And this is what you observe here.
Thanks for this comment and reference to Ehrlich et al 2012. We will modify text to include this aspect.

P8391, 16: "solar radiation" I would change this into "solar reflectivity".
We modified this.

P8391, 23: This assumes that the position of the Sun is in line with the MODIS cross line. This is only valid for the satellite flying at latitudes where the sun stands in zenith position. For other geometries at higher latitudes the scattering angle may differ. It might even become constant for all the swath when the sun is far behind the satellite.
This is correct but statistically for all sun direction, the samples of cloudbow there are

twice that of other part of swath (Please see the figure below).



Figure– *The occurrence frequency of POLDER rainbow directions (scattering angle between 130°-150°) against MODIS viewing angle*

P8392, 1: Typo: "is observed"
We modified this.

P8392, 6-7: This sentence is again written like an introduction but only wastes space. The results follow very soon in the text and that the fact is important is obvious otherwise you would not have presented it. So you can remove this sentence.
We would like to keep the message so the sentence has been replaced with "Especially CALIOP can help establish the lower limit in optical thickness below which a thin cirrus can not be identified when it overlays a lower liquid cloud."

P8392, 9: "strong polarization signature" this is related to POLDER and not CALIOP. Please add this here as the reader might think that it also holds for CALIOP. But CALIOP observes backscattered radiation where spheres have no polarizing effect.
We added "by POLDER" after "be measured".

P8392, 15: How the cirrus cases are choosen? Not all thin clouds observed by CALIOP may be cirrus. Is the -40C threshold used here?
We used the cirrus flag in CALIOP cloud product, which includes temperature information

P8392, 17: OT is the third definition of cloud optical thickness in the manuscript after t and COT. Please use the t
We change OT to t

P8393, 6: Is MODIS high sensibility to thin cirrus due to the IR classification or the SWIR/VIS classification?
We explained at P8392 8-10, we think it's more likely due to IR classification.

P8393, 21-22: There is no discussion why these cases MODIS-ice and POLDER-mixed occur for specific cloud optical thickness. Do you have any explanation?
We add our explanation here, “which means POLDER has mixed signal of both upper thin cirrus and lower liquid clouds in this t range”.

P8394, 2-6: Please do not mix up brightness temperatures and brightness temperature differences. BT-Differences make use of the different refractive indices of ice and liquid water (imaginary part). The refractive index of supercooled droplets is still the same as for warm liquid droplets. So why there should be a problem? Only the 11 _m brightness temperature alone is affected but not the differences.
The phase product is a combination of temperature difference and temperature information, for temperature 238T<T11<268K, if temperature differences fall into ambiguous case, it may mislabel the phase. For example, for 238T<T11<268K and T difference between -1.0 and -0.25, we cant decide which phase they are. Also, the brightness temperature difference test is not perfect in case where droplet sizes are large but crystal sizes are small.

P8394, 10: Remove ”to one year of”. This does not have to be repeated here.
We removed this.

P8395, 20: What does ”unsaturated” mean here?
We meant, “not saturated by the cloud contribution”. We changed the text to read “When the polarization signal does not arise primarily from the cloud, such as in broken clouds situation …”

P8396, Sec. 5.6: Quite short. What about ice and snow surfaces below liquid clouds? This should be a problem to for MODIS-SWIR/VIS and Polder if cloud optical thickness is low.
The polarization of ice and snow is the same to ice clouds. Polarization signal is quite sensitive to liquid clouds even when their optical thickness is very thin. But for MODIS, it can’t at all identify them, as temperature profile used is quite different to the one used in the algorithm and can biases the result.

P8397, 10: ”High confidence”. What if both sensors are wrong? Ok, this can not be validated here. But should be mentioned. 100% agreement between POLDER and MODIS does not mean there is for 100% the correct cloud phase identified.
We have demonstrated when POLDER and MODIS agree, 95% of CALIOP agree with both passive sensors, even more than 99% for ice case. It means the three sensors agree. With current techniques, it results in a high confidence cloud phase product.

P8397, 13: Why the statements are written so general. The general problems have been clear already in the introduction. Now with your study you have much more insight. Details should be repeated in the conclusions.
Please see new text for the conclusion earlier above.

P8397, 29: "high confidence". 75% agreement as shown in the study is not really high in my opinion!
No, high confidence here refers to the > 95% agreements between POLDER, MODIS and CALIOP.

Figure 2: The scaling is misleading. All maps should have the same color code scale. Otherwise a comparison is not possible. Of course, then e.g. the mixed-mixed class can not be seen at all in the plot. Alternatively, you can scale all plots to the total number of observations in each class. Then the plots are not anymore comparable with regard to the numbers but the main outcome of the plots is the global pattern, so numbers do not matter. Theses numbers are already presented in Fig. 1.
We would like to keep the figures as they are currently. Indeed using a fixed color-scale stretch would make some classes totally disappear. We wouldn't see clearly their geographical distribution because some phase percentages are much higher than others. We agree with reviewer that figures are not fully easy to interpret at first glance but we tried several scaling approaches and none would be able to retain all the information we're trying to provide.

Figure 3-4: Here the same scaling problem occurs. When using different scales to obtain a similar color code, then you also can normalize all plots to the total number of observations of each class.
Same as above.

Figure 8: The blue line in panelb is crossing the legend. You can move the legend further right to avoid that.
Done.

Figure 8: Legend in panel a. The letters are overlapping. Please add some more space.
Done.

Figure 8: Description of panel b is missing in the figure caption.
Done: We added "(a) and of 4 combined phases products as a function of MODIS viewing angle (b)

Figure modified:

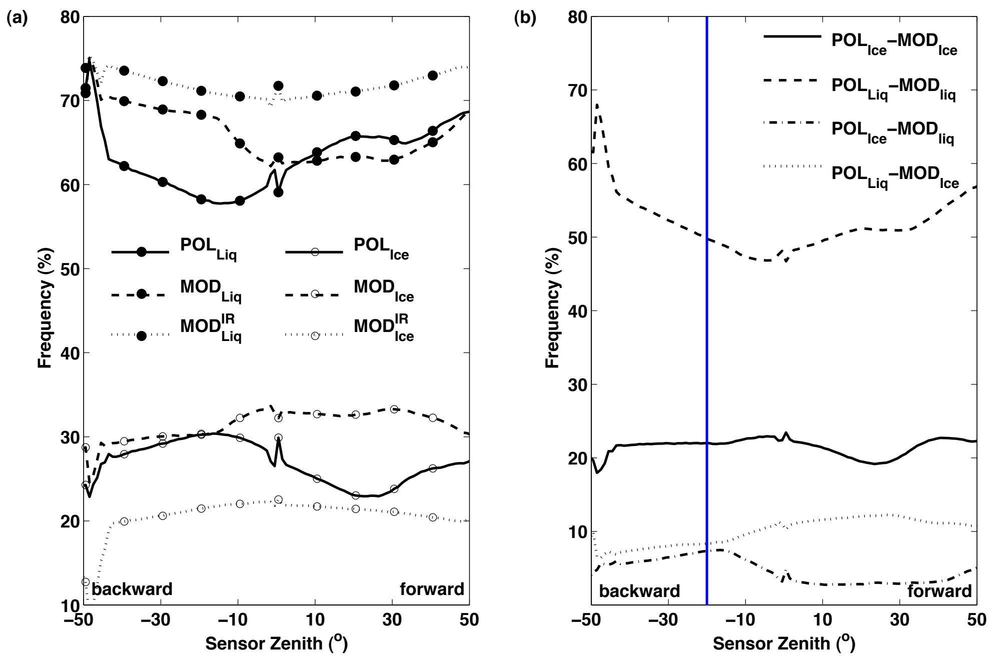

(a)
Frequency (%)
Sensor Zenith (°)
backward
forward
POL_Liq
POL_Ice
MOD_Liq
MOD_Ice
MOD^IR_Liq
MOD^IR_Ice
(b)
POL_Ice–MOD_Ice
POL_Liq–MOD_liq
POL_Ice–MOD_liq
POL_Liq–MOD_Ice

Fig 8.

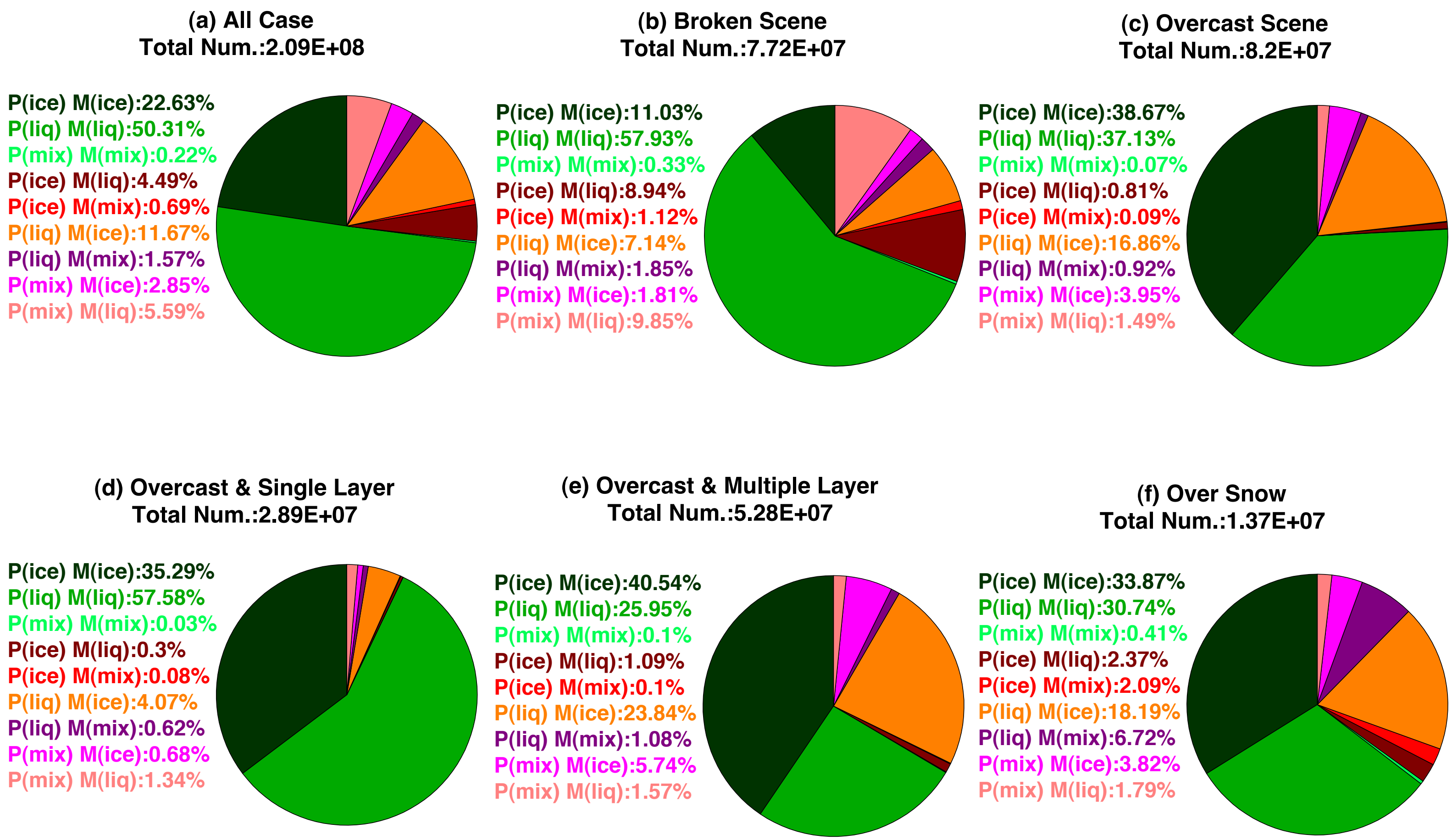
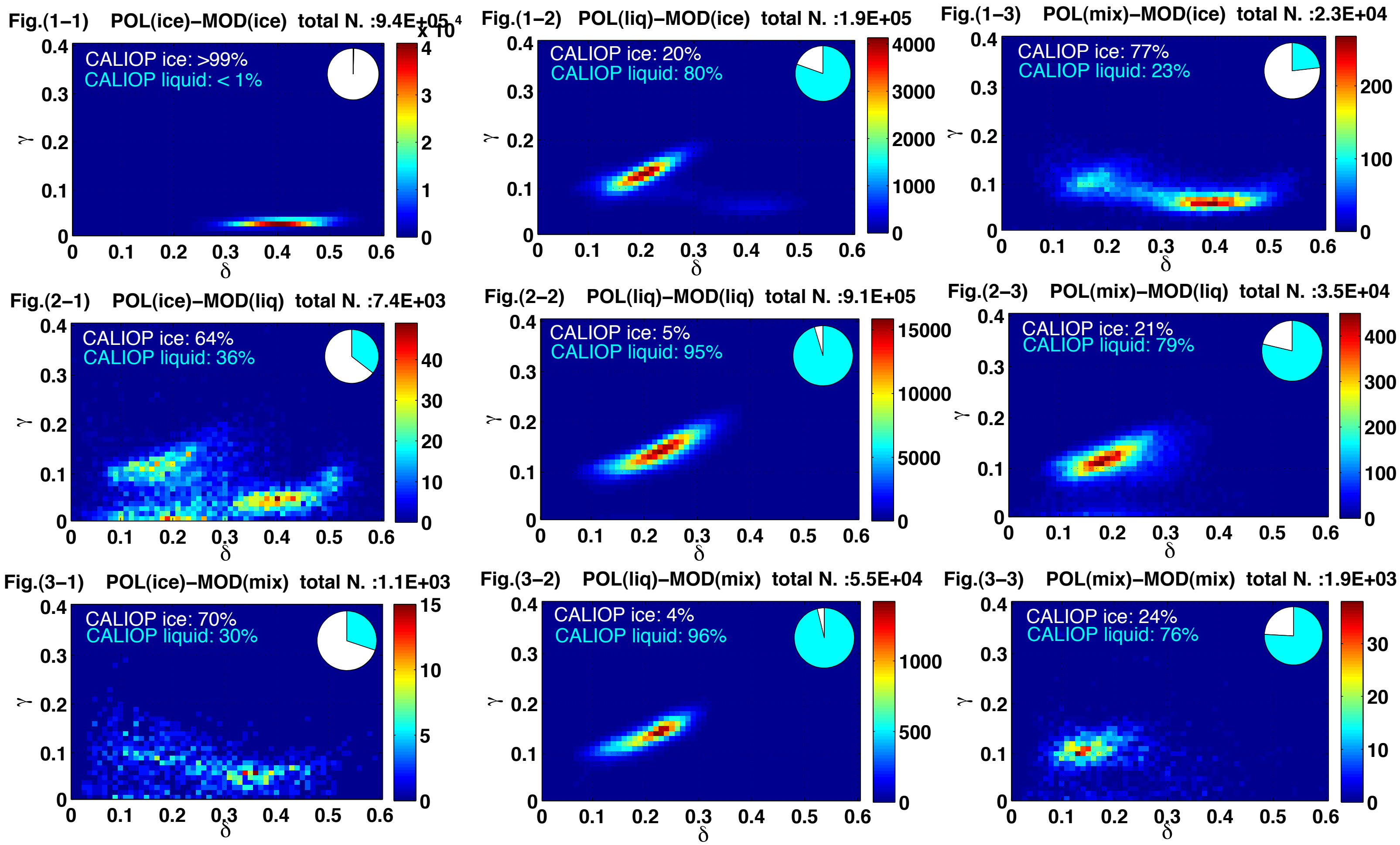
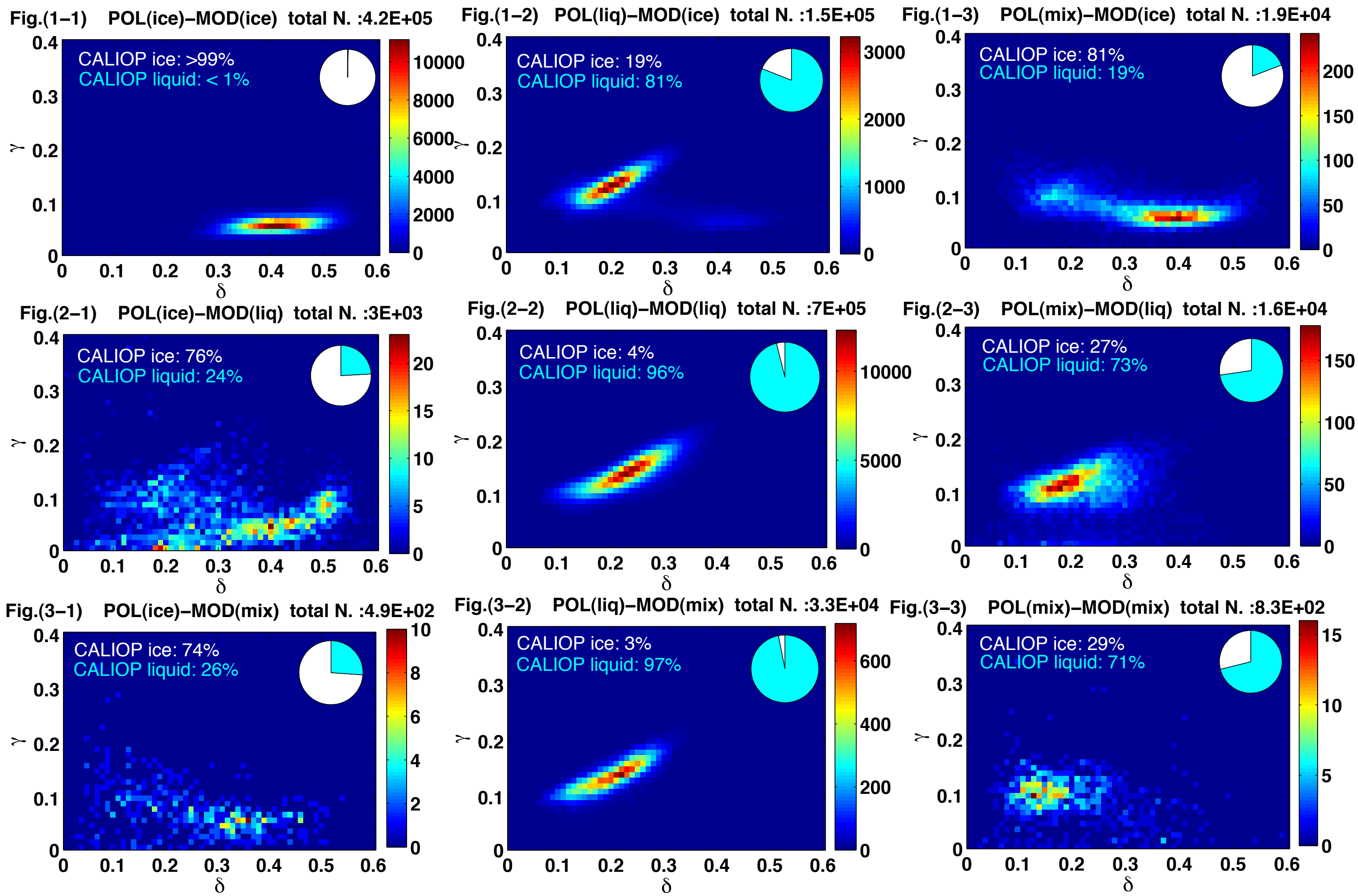

(a) All Case
Total Num.:2.09E+08
P(ice) M(ice):22.63%
P(liq) M(liq):50.31%
P(mix) M(mix):0.22%
P(ice) M(liq):4.49%
P(ice) M(mix):0.69%
P(liq) M(ice):11.67%
P(liq) M(mix):1.57%
P(mix) M(ice):2.85%
P(mix) M(liq):5.59%
(b) Broken Scene
Total Num.:7.72E+07
P(ice) M(ice):11.03%
P(liq) M(liq):57.93%
P(mix) 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%

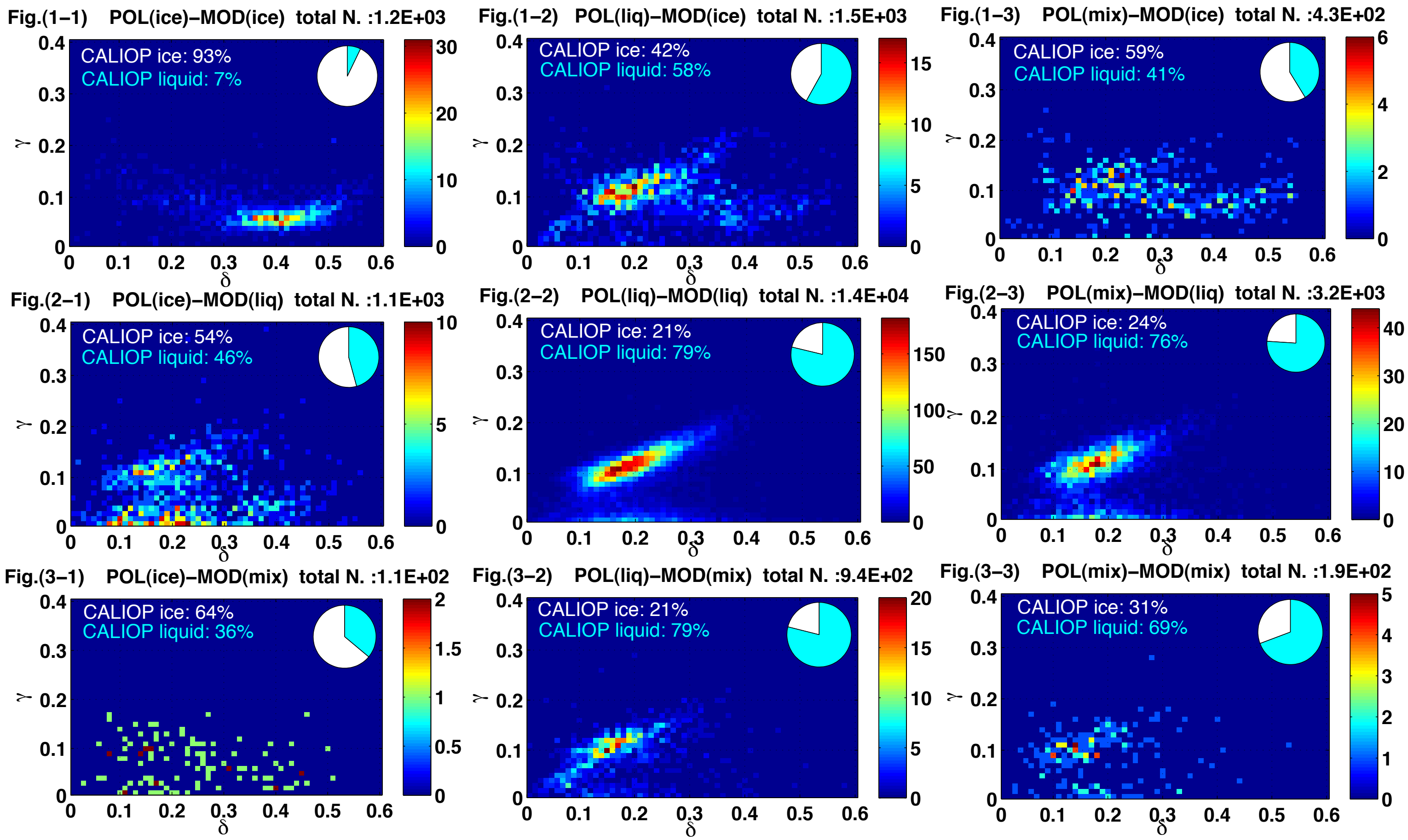
Fig 1.



Combine Fig 3. & 5 for all clouds



Combine Fig 4 & 6 for overcast clouds



For broken clouds