Response 1 to Referee #3 Comments (received 11/07/2011)

We have to press again on the point that the aim of this paper is to introduce the technical specifications of PHIPS and PHIPS-HALO to the scientific community. That's why we have chosen AMTD for the publication. A more scientific work (which obviously needs more data) will be published once enough laboratory and field data is available from the PHIPS-HALO version.

As mentioned in AC C1021, the reader can notice that we used the term "correlated measurements" in terms of a parallel or simultaneous measurement of the particle habit and the angular light scattering function. It was not our intention to present a detailed correlation analysis of particle properties. In that case we would have rather used the term "measurements of correlated particle properties" or "correlation study of ..." which may be included in the title in a later publication.

Discussing the points mentioned in the second and third paragraphs of page C1061 (by the referee) in this paper could drift us away from the goal of this paper. Such a detailed study was reserved for a scientific paper. We prove here the validity of PHIPS by the two given examples as well as by a comparison with other instruments. However, we appreciate that the referee addressed to us important points on which we should focus when writing the expected scientific paper from the future PHIPS laboratory and field data. Nevertheless, we should notice here that because of the fixed orientation and the linear detector array measuring at just one azimuthal angle, one cannot determine the asymmetry parameter using PHIPS. According to the definition of asymmetry parameter by Bohren & Huffman,'Absorption and Scattering of Light by Small Particles',p.72:

g = <cos(theta)> = integral over 4Pi (phase function * cos(theta)) dOmega

A similar definition is in Mishchenko, 'Light Scattering by Nonspherical Particles', p.19. Since PHIPS measures the intensity distribution only in one plane and the particle orientation is fixed, we cannot integrate over 4Pi. The aim of the instrument is particle classification. However, if we do measurements for many particles, we could determine an average asymmetry parameter. (Not sure, if there are any normalisation problems between different particles). And probably this measurement over an ensemble needs to be emphasized.

Concerning the second paragraph of page C1062, the following sentence will be added to the introduction behind "… wrong optical parameters of the whole particle ensemble."

"Although sophisticated optical models for the computation of the scattering properties of irregularly shaped ice particles have been developed over the last 20 years (e.g. Takano and Liu 1995, Yang et al. 2000) there are still discrepancies between the cloud radiative properties derived by space born remote sensing and those derived from in situ microphysical properties using sophisticated libraries of single scattering properties (Baum et al. 2010).

The referee discussed particle shattering.

Yes, there is a big “*concern that shattering of large particles on the sampling tube could cause small ice crystals to be swept into the sample volume in much the same way that occurs with other cloud probes*” in the case of PHIPS-HALO which is under construction at the moment. Discussions as well as aerodynamic studies are currently being conducted in order to minimize this problem. In case of the laboratory version of PHIPS, however, there is no concern from shattering problem since particles are sampled through a tube of 10mm internal diameter with a speed of 2m/s (laminar flow is guaranteed).

Concerning the response time of the instrument, the question was: “*will the response time of the instrument be sufficient to detect particles when operating at the true air speed of an aircraft?*”

PHIPS has two detection systems (Scattering and imaging). The scattering part uses the same electronics as SID2 and SID3 instruments which were already tested and operated on aircrafts. The response of the imaging part relies on the illumination device (flash). In PHIPS-HALO we use an incoherent Laser as an illumination for the imaging system. This laser has a temporal pulse width down to 10ns. This corresponds to a displacement of 2µm for a particle travel through the instrument with a speed of 200m/s (HALO air craft speed).

The Referee wrote:

“*Finally, the authors note the small detection volume for the PHIPS. Hallett (2003) examined the statistical significance of a measured particle size distribution by computing the integration time or distance that an aircraft would need to fly to measure at least 100 particles in each size bin. This could provide an interesting context for stating the sample volume of PHIPSâ˘A ˘ Tto me, this is much easier to understand than the statement that the maximum acquisition rates are 262 KHz and 10Hz for scattering phase functions and images*.“

These maximum acquisition rates show the maximum rate of particle detection from the technical side of PHIPS. When we have a specific experiment under specific conditions (particles speed, cloud density), one can calculate the exact acquisition rate under these conditions. An example: when we operate PHIPS-HALO in a typical Cirrus cloud situation (about 100 particle/Liter), the distance (spatial resolution) for which we can generate a reliable particle size distribution could be 40km (if we assume 10 size bins of 100 particles per size bin). The resolution we come up with is not very good but here we state again that it is not the intention to measure with a high statistical significance but to get good measures of the scattering function for individual particles which can be used to validate the optical particle models.

The Referee wrote:

"… In fact, Korolev et al. (2003) found that about 98% of ice crystals measured in arctic clouds were irregular rather than having idealized shapes for which scattering libraries are available (e.g., bullet rosettes, columns, plates, aggregates of columns, dendrites, hollow columns, etc.). A big advantage of PHIPS in such situations is that the scattering phase function will be directly measured. However, I'm not sure how the two views will retrieve the 3-d cloud structure in such cases."

Actually (as mentioned in lines 17 to 26, page 2891), constructing a 3-D image is only possible for regular geometric shapes (like rods, columns, plates). In the case of more complex habits a construction of a 3-D model from two cameras is impossible; however, it is still possible to reduce the scatter in results, when plotting size distribution for example, by selecting the larger evaluated size from the two images of each particle.

Referee Minor Comments:

R#3: "*Page 2891, line 23. I would say that rosettes are a pristine habit. There are much more complex habits that exist, and these complex habits may dominate in some situations*."

AC: "rosettes" will be replaced by particle aggregates.

R#3: Page 2893, line 14, "pass" instead of "path"
AC: Done

R#3: Page 2896, line 16, remove "for this purpose"
AC: Done

R#3: Page 2898, particle classification. There are far more complex particle classification techniques in existence (e.g., differentiating rosettes, columns, plates, aggregates, etc.). Perhaps provide the context of the classification algorithm being used here.

AC: This is just the beginning of a more sophisticated classification scheme which will be implemented after the data base has been improved (e.g. deploying the new PHIPS-AIDA in a series of AIDA experiments to classify more complex shapes as well).

R#3: Figure 3, is this figure needed?

AC: Not really needed because the message is quite simple (can be explained in the text) and because the principle behind the figure has been already discussed in earlier paper (Schön et al. (2011).