We thank the reviewer for his/her critical assessment of our manuscript. Our replies (in standard text) to the reviewer's comments (italic) are as follows:

This manuscript presents a novel design for a ground-based inlet that extracts ice crystals from mixed-phase clouds using a combination of an impactor, a phase discriminating flow tube, and a counterflow virtual impactor. To my knowledge this is only the second phase discriminating inlet, after the ice-CVI referenced in this paper. The paper is of importance to the field, is well written, and the topic is appropriate for AMTD

Unfortunately, this manuscript falls far short of the standard of a peer-reviewed paper. The central issue is that there is an entire section missing, which is any sort of experimental validation of the technique. The paper starts with a presentation of the concept of the technique – which is theoretically sound. There is an extensive discussion of the WELAS instrument used to observe exiting (that is, in theory) ice crystals. The new inlet was then brought to a location of mixed phase clouds, a mountain-top Swiss site. There is one plot of observations and one plot of optical output after the inlet.

This paper is not publishable until there is a comprehensive section on inlet testing and determination of transmission. I can find no other paper on this type where a set of controlled lab experiments were not performed. In essence, the reader is asked to believe the theory translates perfectly to performance. Why is there no data using e.g. lab-produced droplets to show the phase discriminator fully evaporates these and the CVI rejects them? Why is there no laboratory preparation of ice crystals where they are shown to be transmitted through the phase discriminator and passed through the CVI? These tests would allow (1) quantification of some portion of the inlet artifacts and (2) quantification of the transmission efficiency.

As it stands now, the authors attempt to suggest that each of the inlet segments will work exactly perfectly . . . except that they have neither tested all together or tested the phase discrimination setup. Indeed, the authors mention an observation of highly rounded ice residuals by the optical detector is not convincingly separated from slightly aspherical droplets as would be the case in a turbulent flow. They argue this is sublimation, which maybe it is. Put more directly, there is no presented evidence that refutes the transmission of droplets through the inlet interspersed with ice crystals. Since the target of the new inlet is mixed phase clouds, which can be (greatly) dominated by droplets over ice and often with similar size, it is stunning that some type of testing wasn't performed before field deployment and certainly before attempted publication.

In conclusion, this manuscript describes a novel inlet of importance to the study of clouds and the aerosols upon which they form. Rejection is suggested, however, since the authors have skipped what should have been a relatively simple and absolutely critical step of a laboratory validation of a new technique. As currently constituted, this paper does not convince that the inlet works as theoretically devised.

We have added a discussion of the transmission efficiency of the omni-directional inlet and cyclone based on model calculations (Sect. 2.3 in the revised manuscript) together with a new figure (Fig. 2). We have also added a discussion of the transmission efficiency of the droplet evaporation unit based on cloud particle measurements recorded using the WELAS sensors mounted above and below the droplet evaporation unit (Sect. 3.3 in the revised manuscript), also with an accompanying figure (Fig. 13).

As regards tests using lab-produced droplets or ice crystals, we conducted such tests but encountered major difficulties. Lab experiments using droplets or ice crystals require a chamber with very well defined temperature and supersaturation conditions – otherwise the ice crystals and droplets are not in a stable state and the particles could evaporate (or grow) even without any influence from the inlet. Consequently, any attempt at lab characterizations has to be carried out in a state of the art facility, such as the Aerosol Interaction and Dynamics in the Atmosphere (AIDA) cloud chamber at the Karlsruhe Institute of Technology, Germany (see, e.g., Möhler et al., 2005 for details on the AIDA chamber). Indeed, we have attempted to characterize the droplet evaporation unit during the IN-19 campaign on heterogeneous ice nucleation, conducted in 2012 at the AIDA. We conducted two types of experiments at the AIDA, which are quasi-adiabatic expansion and spray experiments. In the case of the expansion experiments, the clouds are induced by quasi-adiabatic expansion cooling of the chamber. However, there are several issues with this type of experiment. Firstly, the cloud formed in the chamber is transient, lasting only on a timescale of minutes (maximum time of a supercooled liquid cloud at -20ºC is about 10 minutes). There is a continuous loss of cloud particles to the chamber walls via sedimentation and turbulent diffusion. If the expansion cooling is stopped, as the temperature of the walls lags behind the decreasing air temperature, heat is transferred from the walls to the air, and rapid evaporation of the cloud particles takes place. Secondly, similar to the cloud chamber walls, the temperature of the droplet evaporation unit also lags behind the very rapid decrease in air temperature during the expansion. Meanwhile, for the droplet evaporation unit to function its temperature must closely follow that of the air – this is an underlying principle of its functioning. Such conditions are unfortunately not attainable during a quasi-adiabatic expansion experiment at the AIDA cloud chamber.

In the case of spray experiments, the hydrometeors are generated by spraying droplets into the chamber. During these experiments, the droplets were successfully removed by the evaporation unit. Thus, the operation principle of the evaporation unit was proven. However, a quantitative assessment of the removal is difficult as we expect the warmer droplets equilibrate thermally with the colder chamber temperature by evaporative cooling. This thermal equilibration is ongoing during the sampling period. During the experiments the chamber temperature is below 0°C and the walls of the AIDA chamber are ice covered. As a result the AIDA vessel itself acts as a large “droplet evaporation unit” and the injected droplet ensemble is gradually evaporating. In such an experiment we expect the temperature and the relative humidity to increase along an axis from the cold ice covered chamber walls to the center of the injected warm and liquid droplet cloud. Therefore, droplets which are not fully equilibrated are sampled through the evaporation unit. Inside the evaporation unit the walls are closer and the droplet removal is enhanced. The transient nature of the injected droplet cloud itself thus hinders a quantitative assessment of the effect of the evaporation unit. Furthermore these tests were carried out with inlet and evaporation unit versions that were not used further. For future laboratory tests of the ISI a new cloud chamber type with cooled walls and thus more stable mixed phase clouds should be used.

We conclude that given the available data and the current AIDA cloud chamber setup field measurements provide a better opportunity for validation of the inlet operating principle – the clouds are much more long-lived and temperature fluctuations are much slower, allowing for the droplet evaporation unit temperature to follow the air temperature.

Regarding the reviewer’s concerns that there is insufficient evidence that all droplets are removed in the droplet evaporation unit, and that slight deformation of droplets due to turbulence in the inlet could result in droplets becoming aspherical and being mistaken for rounded ice crystals, we argument as follows:

Firstly, we performed experiments at the AIDA cloud chamber during which only droplets could exist due to the thermodynamic conditions. The distinguishing between ice and liquid droplets by the PPD-2K is based on the azimuthal symmetry of the scattering patterns. As displayed in the revised Fig. 12 droplets have an almost perfect azimuthal symmetry as opposed to ice particles. A detailed discussion of the PPD-2K’s ability to distinguish between ice particles and liquid droplets is given in Vochezer et al., 2015 (submitted to AMT). In the course of pure liquid cloud experiments at the AIDA cloud chamber no rounded patterns, such as the ones displayed in figure 12c, were detected. The PPD-2K was run with the same flow settings at the AIDA chamber and during the CLACE campaigns, therefore we expect the performance of the PPD-2K to be unchanged.

Moreover, during maintenance times the evaporation unit was dismounted but the remaining parts of the ISI continued cloud sampling. During such periods the PPD-2K recorded mainly droplet patterns and not the rounded patterns displayed in Fig. 12c.

Further proof that the rounded patterns are not due to misclassification of droplets as ice crystals is that during CLACE 2014, when a shorter and smaller evaporation tube was used (residence times for a 20 µm ice crystal decreased from ~230s for the CLACE 2013 evaporation unit to ~30s for the CLACE 2014 evaporation unit, as per model calculations) we saw fewer rounded patterns. If the rounded patterns recorded during CLACE 2013 were droplets, we would have seen more of them when using an evaporation unit with shorter residence times. As the opposite was true, we conclude that the rounded patterns recorded during CLACE 2013 were indeed sublimating crystals, and were less frequent in CLACE 2014 due to a lower residence time in the evaporation unit and, thus, less modification of the ice crystal structure during its transport through the inlet.

To answer also the specific concerns of the reviewer that the highly rounded ice crystals presented in Fig. 12c could be slightly aspherical droplets from a turbulent flow: based purely on a simple calculation of the Reynolds number (Re) for the flow inside the WELAS and PPD-2K, the flow could be turbulent (Re=2520 and RE=6600 for the WELAS and PPD-2K respectively). It is furthermore true that deformed liquid droplets could lead to the rounded patterns displayed in figure 12c. However, as described above, such rounded patterns are not recorded by the PPD-2K during pure liquid cloud experiments at the AIDA. During the CLACE measurements there was an additional potentially turbulent flow in the WELAS (Reynolds number in the WELAS is in the transition regime) before the PPD-2K as compared to the AIDA measurements where the PPD-2K sampled directly in-cloud. However, that should have no influence as (i) the Reynolds number is much smaller in the WELAS than in the PPD-2K and (ii) droplets smaller than 1mm in diameter are practically spherical even when falling at terminal velocity (Beard, 1976). Furthermore it is doubtful that the potential turbulence in the ISI would induce sufficient shear stress to deform the droplets. As regards the droplet evaporation unit itself, the Reynolds number is very low (Re=40 during CLACE 2013 and Re=134 during CLACE 2014) and therefore the flow is laminar.

We therefore conclude that potential turbulence in the ISI does not cause slightly aspherical droplets, neither at the AIDA nor the ISI, to appear in the PPD-2K, and that the presented rounded patterns correspond to rounded ice crystals rather than misclassified droplets.

We believe we have presented very strong evidence that the droplet evaporation unit removes droplets very efficiently, based on the Particle Phase Discriminator (PPD-2K) measurements, as opposed to the reviewer's comment "*there is no presented evidence that refutes the transmission of droplets through the inlet interspersed with ice crystals"*. As stated in the manuscript, during the case study period only 0.8 % of transmitted particles in the sampled mixed phase cloud were identified as droplets. Throughout the campaign, as during the case study period, it was verified that the vast majority of scattering patterns recorded by the PPD-2K were representative of ice crystals – in our opinion, together with the presented evidence showing that the rounded patterns measured during CLACE 2013 were rounded ice crystals, this is conclusive proof that the droplet evaporation unit efficiently removes droplets from the sample flow.

To sum up, as described above, we have attempted to characterize the droplet evaporation unit in the AIDA cloud chamber – a controlled laboratory environment – however, due to the aforementioned issues with such measurements, we are of the opinion that field measurements are a much more reliable platform for instrument characterization in this case. Furthermore, we have shown that droplets are removed from the sample flow, based on the single particle measurements conducted with the Particle Phase Discriminator. Finally, we have included transmission characteristics for the omni-directional inlet, cyclone and droplet evaporation unit, as suggested. We believe we could thus adequately answer all of the reviewer's concerns raised above.

Upon resubmission: (1) there needs to be a comprehensive laboratory study with quantification of transmission of droplets and ice residuals – show the former is not transmitted experimentally while the latter is (2) instead of the final optical figure field data should quantify the transmission of droplets versus their presence in the cloud as well as the transmission of ice crystals. This should be presented analogous to the experimental data to show the inlet works at the different pressure and more rigorous field conditions. Ideally, a comparison should be made to the current "state-of-the-art" ice-CVI which, per referenced publications, has been located at the same research site during these field studies.

We have included a new figure (Fig. 13) in the revised manuscript showing the average transmission efficiency of droplets and ice crystals through the droplet evaporation unit based on measurements during CLACE 2013 and CLACE 2014, where a redesigned evaporation unit with shorter residence time was deployed (thus decreasing ice crystal sublimation and losses).

A comparison with the Ice-CVI is not possible in this case, as there are no sensors within the Ice-CVI itself to measure the cloud particle size distributions or scattering patterns.

Suggestions and references:

In researching the CVI, I note that the authors of this manuscript do not fully consider the pressure effects noted in Boulter et al., 2006. While the paper is referenced here the authors seem to perform some CVI checks on transmission but don't explain differences when operated at the altitude of the mountaintop station (that is to say, apparently the lab settings were transferred exactly which would not appear to be correct?). Boulter et al., 2006 suggested significant differences. This pressure dependence should be quantified.

It is hard to quantify the effect of pressure changes on the PCVI transmission efficiency from the Boulter et al. (2006) paper, as they change the flow settings for each of their experiment runs, which themselves are the primary determinant of the transmission efficiency. Furthermore, the PCVI model used in our measurements is the newest commercially available PCVI (model 8100, Brechtel Manufacturing Inc., USA), i.e., a follow-up of the PCVI described by Boulter et al. (2006) and thus in general the measurements of Boulter et al. (2006) should not be used as a direct reference for our PCVI performance.

We have not performed tests with the PCVI at Jungfraujoch pressure (typically ~650 mbar). However, colleagues at the Leibniz Institute for Tropospheric Research (Leipzig, Germany) have recently tested the pressure dependency of the PCVI using a pressure controlled vessel as the sample volume. For a set pressure of 600 mbar they found good agreement of the transmission efficiency with that measured at a pressure of 1000 mbar (L. Schenk, Institute for Tropospheric Research, personal communications), albeit with a small shift of the D50 aerodynamic diameter by 0.5

µm from 4.6 µm to 5.1µm. Consequently, we conclude that the PCVI performance is not considerably affected by the difference in standard pressure and pressure at the Jungfraujoch.

Pekour et al., AS&T, 2011 have performed a study of CVI artifacts. It is surprising this isn't referenced here, nor are the artifacts described in detail. It would be good to know if these artifacts are observed with this inlet.

We have added a reference to Pekour and Cziczo (2011) in Sect. 2.6 of the revised manuscript and acknowledge the artifacts described within as a possible source for the occasional transmission of sub-micron particles during the laboratory characterization.

Unfortunately, it is not possible to say whether any PCVI artifacts are present during the ISI field measurements. This is simply because we are conducting ambient measurements where the ice residuals measured are polydisperse. Therefore, we cannot make a statement for any given particle detected as an ice residual (IR) downstream of the ISI whether it is a real IR, or whether it was a measurement artifact.

To elucidate further, during their PCVI artifact characterization Pekour and Cziczo (2011) dispersed particles with defined sizes (1 µm and 5 µm), with the PCVI cutoff being set to a size between 1 and 5 µm. Therefore, if they measured 1 µm particles downstream of the PCVI they knew these were an artifact of the PCVI. Furthermore, they conducted experiments during which only 1 µm particles were dispersed. In this case, practically no artifacts (i.e. no particle transmission through the PCVI) were observed. Therefore, they concluded that transmission of small particles was only an issue when particles above the PCVI cutoff size (i.e. the 5 µm particles) were also present in the sample flow. The transmission of artifact particles is thus dependent on the concentrations of particles both above and below the PCVI cutoff size. A simple method for checking whether artifact particles cause any significant contamination is by comparing the characteristics, such as the chemical composition, of the total aerosol and the aerosol measured downstream of the PCVI (ISI ice residuals). If the particles measured downstream of the PCVI were artifact particles one would expect them to have very similar characteristics to the bulk aerosol. Meanwhile, as shown in Fig. 16, the ratios of fluorescent to all particles measured downstream of the ISI and downstream of the total inlet during a Saharan dust event differ considerably, i.e., the particles measured downstream of the ISI have different characteristics to the bulk aerosol which is strong evidence that the dominant fraction of these particles are indeed ice residuals.

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