We thank the referee for his valuable comments to improve the quality of the manuscript. Below we will give a point-by-point answer to the individual comments. The answers are highlighted in blue.

As a general comment I want to state that the paper is sort of lengthy – there are information provided, that are well known and must not be repeated. This is in particular true for the part describing the formalism of the depolarization ratio: in the present state it is more confusing than helping because of the inconsistent nomenclature (a lot of different "depolarization ratios" are introduced, which is neither necessary not as exact as it should be; by the way, lidar researchers should know about this stuff). Moreover, the extensive description of the conduction of the nucleation experiments can be explained once (for the lidar people), but maybe not three times.

As far as the comprehensive description of the depolarization ratio is concerned, we disagree with the referee. The primary intention of the paper is to introduce an in-situ lidar related set up as a novel measurement technique for researchers that mainly work in the laboratory (but also e.g. on mountain stations) in the field of cloud microphysics. These people are in general not familiar with the mathematical formalism behind the lidar depolarization measurement (of course the lidar researchers are). Moreover, the formalism for the depolarization measurement off 180° is different from that at the lidar angle which is a special case of the general angular dependent theory. Therefore, we think it is necessary for interested researchers, who plan to use the SIMONE technique, to give the fundamental equations of the measurement in a specific representation along with the technical details.

We also do not see an “inconsistent nomenclature” of the depolarization ratios that we introduced in Sects. 2.1 and 3.1. The subscripts H and V in $\delta_{H,V}$ refer to incident light that is polarized parallel and perpendicular with respect to the scattering plane, exactly what we measure with SIMONE. This nomenclature is widely used in the literature on the modeling of the angular depolarization properties of ice particles (e.g. Takano and Jayaweera, 1985). We then introduced the lidar depolarization δ_{lidar} as a specific case of the above angular depolarization ratio, namely the depolarization at exact backscattering angle. There, the depolarization ratio is independent of the incident laser polarization. Additionally, we used the symbol δ_l in the Introduction (Sect. 1) as a general term for linear depolarization measurements that are conducted with lidar systems in the atmosphere and we used the term δ_{SIMONE} in Sect. 5 of the paper. Here, we agree with the referee that these terms are inexact. We therefore changed the nomenclature to δ_p to emphasize that the particle linear depolarization ratio was measured in the studies reviewed in Sect. 1 and to $\delta_{H,V}$ when referring to SIMONE measurements. We also changed the sentence on 15459/22-23 to “From these measurements the near-backscattering particle linear depolarization ratio $\delta_{H,V}$ is determined by “, to make clear that we measure and analyze particle depolarization ratios.

We agree with the referee’s comment on the extensive description of the conduction of the nucleation experiments. Therefore, we significantly reduced the descriptions of the experimental procedure in Sections 4.3.2 and 4.3.3.

15454/4: 488 nm is not a lidar wavelength. Thus, the results must be extrapolated to 532 nm, 355 nm or even 1064 nm. A comment on this fact and the consequences should be added. In case of aerosols there is a wavelength dependence.

The prototype versions of SIMONE used an Ar-Ion laser, so the anti-reflection coatings of all optical components (mirrors, windows, Glan-Laser prism) were optimized to the Ar-Ion wavelength of 488 nm. That’s why we decided in later versions of the instrument not to change the laser wavelength. However, the wavelength is only 9% off the widely used lidar wavelength of 532 nm. Within this percentage and except for ice particles with equivalent sizes below about 2 microns, the depolarization ratio has roughly the same (maximum)

dependence on wavelength. However, the direction of this discrepancy depends on the ice crystal size and shape and cannot be generalized (see e.g. Mishchenko and Sassen, 1998).

15454/8 and throughout the paper: LIDAR should not be capitalized (in the 21. Century it can be treated as a word, not as an acronym).

We agree and changed the wording accordingly.

15456/8: what is the linear depolarization ratio of CALIPSO: the “particle linear depolarization ratio” or the “volume linear depolarization ratio”? In case of cirrus clouds the difference certainly is small nevertheless, the manuscript must be precise. This applies to the whole text, especially when measurements are compared that concern different “depolarization ratios”!

See answer to the first comment above.

15456/20ff: the examples mentioned here all show very large values inconsistent with the results from SIMONE shown later in this study. So, why are these references cited, or what is the reason for the discrepancy?

We cited these lidar measurements here because they all show that in case of the small particles in contrails and contrail cirrus the measured depolarization ratio is generally high. We found a similar trend in our data towards the small size range, i.e. shortly after the ice nucleation has initiated or in the final stages of the sublimation process. So, high depolarization values that are observed in these investigations are likely due to the presence of small ice particles. We conclude this on 15480/20ff and 15482/17ff.

15456/24: “the knowledge of the link. . .”: this is indeed a crucial point, note that the variety of “real” ice crystals is much larger than discussed in this manuscript. Moreover, the orientation of the crystals influences the lidar signals. Thus, this paper can give some (useful) information but will not provide the missing link.

We do not claim to provide the missing link, we only say that we investigate the link (cf. 15457/1ff: “In order to investigate the relation between the linear backscattering depolarization ratio δ_l and the microphysical properties of small ice particles that might closely resemble those in contrails and cirrus, we have started to perform …”

15459/23: _p _H _V how are they related? What is the relevance of the latter two for lidar measurements?

The depolarization ratios _H and _V have no direct relevance for lidar measurements. However, these ratios are important in off-backscattering depolarization measurements to deduce the scattering matrix elements S22/S11 and S12/S11 which are the direct outputs of particle optical models.

15461/15: Figure 1 is explained after Figs. 2-5; thus, the order of the figures should be changed; or rearrange the text.

We changed the order of the figures.

15464: _LIDAR: this is the fourth or fifth “depolarization ratio” in the text. Sij and k are not explained here (only two pages later). Please check, how the whole section 3.1 can be reduced to those parts that are really required for the understanding of the data evaluation and the link to the lidar measurements.

The depolarization nomenclature will be revised and presented more clearly in the final manuscript.
We changed the wording of the first sentence of Sect. 3.1 to: “For the theoretical analysis of the measurements at the AIDA chamber, we need to express the depolarisation defined in Eq. (1) by the elements S_{ij} of the 4 x 4 Mueller scattering matrix **S**.”. We also changed sentence 15464/1 to “The constant *R* is the distance from the scatterer and *k* is the wavenumber.”

15465/10: the authors assume (among others) cylindrical particles. A comment why hexagonal forms are not considered must be added.

We agree and added the following sentence behind the first sentence of Sect. 3.2:
“We used this method because it was applied in the study by Mishchenko & Sassen (1998) for the interpretation of lidar measurements of small ice particles in contrails and contrail cirrus. We are aware of the fact that spheroidal and cylindrical particle shapes are only rough approximations of the hexagonal morphology of natural ice particles.”

15466/14: If virtually all details are explicitly written as equations, a formula for ”b” should be given for reasons of “homogeneity”. Or reduce the whole formalism (see above).

Since the prefactor *b* is experimentally deduced in the experiment with supercooled water droplets we did not present the explicit equation at this point. However, we inserted the following sentence in 15466/15: “The prefactor *b* was deduced in a droplet experiment that will be discussed in Sect. 4.1.”

15468/3ff and rest of the paper: I am not sure whether it is necessary to explain in detail how the freezing-experiment was done – at least from the lidar-point of view, this is of minor importance. This is in particular true as this type of information is repeated for each subsection.

See answer to the general comment above.

15475/22ff: It should be stated, that this fact is well known (see 15477/9ff); not a new finding of this paper. It is not necessary to repeat this a third time on 15481/25ff.

We removed the sentences on 15475/22ff and 15477/9ff but leave the sentence in the Section on the atmospheric implementations (15481/25ff).

15477/28: “ellipsoidal scattering pattern”: this cannot be understood here. The reference to the subsequent section is correct but does not help the reader. I recommend to skip this sentence here; it is sufficient to mention the scattering pattern where it is discussed (the authors often mention something which is only explained much later – this could confuse the reader).

We have removed this sentence as suggested.

15480/15: “This means. . .”. I don’t understand this conclusion, in particular, as most (or all) lidars do not change the polarization of the emitted radiation (as radars do). So, what is the message?

The point here is: depolarization measurements outside the exact backscattering angle are in general dependent on the polarization direction of the incident light. Or in other words, such measurements are affected by the matrix element S_{12} which is essentially equal to the polarization property of the scattering particles. This is not the case for the lidar angle (180°) as correctly stated correctly by the referee.

When comparing Eqs. (10), (11), and (12), it can be seen that in the case of S_{12}=0 all three depolarization ratios become equal, i.e. $\delta_H = \delta_V = \delta_{lidar}$. This means in turn that a change in the incident polarization does not change the result of the depolarization measurement for the SIMONE detection angle. Consequently, the measured depolarization ratio is not influenced by a possible contribution from the polarization property of the particles (which is always the case for lidar measurements). Of course a possible discrepancy due to the different detection angles still remains.

15480/11ff: in Fig 13 (lower right) the differences of S22/S11 for 178 and 180 degrees is discussed. As the quantity of interest is _p the authors should show this difference (can easily be calculated from Eq. 15). Only then it is possible to directly see the possible errors of _p due to the angular extrapolation towards 180 degrees, if the value at 178 is used (according to Fig. 13 this difference can be large). Why is the small difference between _H and _V (see 15480/15) an indication that the depolarization ratio at 178 can be used for 180 degrees? This issue is relevant for any lidar application; thus, the arguments should be convincing.

As mentioned in the answer to the last comment, the small difference between _H and _V indicates only a minor contribution from particle polarization. This is one prerequisite for a comparison of SIMONE depolarization data with lidar measurements. If there is a significant contribution from particle polarization, both depolarization ratios _H and _V have to be measured to eliminate this contribution before a comparison is possible.

This correction for the contribution from particle polarization does not correct for possible discrepancies due to the slightly different detection angle of SIMONE compared to lidar instruments. This can be estimated by comparing the modeled S_{22}/S_{11} values at the SIMONE detection angle of 178° with those at the lidar angle of 180°, as we did in the lower right graph of Fig. 13, or by comparing directly the depolarization ratios that can be calculated from Eq. (12) as suggested by the referee. We will follow this suggestion and change the figure accordingly.

15480/22: When discussing real lidar measurements, the presence of large ice crystals and the implications for _p should be briefly addressed.

We have added the following paragraph to 15481/11: “At this point, we want to briefly note that in contrast to the presented chamber experiments large ice crystals often coexist with small ice particles in cirrus clouds. According to our chamber studies with large ice crystals (Amsler et al., 2009, Schön et al., 2011, Abdelmonem et al., 2011), these particles show a broad range of δ_p values from 0.04 to 0.4 depending on the particle size and shape. Therefore, the depolarization from small cirrus ice particles might be significantly masked by the presence of a few large ice particles.”

15481/28: The relevance of hexagonal particles and the modeling of their optical properties have already been shown many years ago, e.g. Hess and Wiegner (1994; Applied Optics), who provided a data base.

The data base by Hess and Wiegner cannot be applied in the present work since it is solely based on geometrical optics and does not account for diffraction which is a significant contribution to light scattering in case of small ice particles.

15482/12: “absolute backscattering linear depolarization ratio”: one more depolarization ratio. Please homogenize the wording and the nomenclature.

See answers above.

15483/7: What is the reason for choosing the FDTD and not DDA. Are the particles too small for the Geometrical Optics Approximation?

See comment above. DDA is indeed applicable to ice particles sizes of a few micrometers.

Conclusions/results: The authors should think about a summarizing table including the most relevant findings (lidar relevant optical properties): nucleation process/particle size/temperature/_p. This would be more helpful than the information given in Tab. 1.

We agree with the referee and change Tab. 1 accordingly.

Fig 13: the figure caption of the lower right panel and the legend do not agree.

We will change the lower right panel of Fig. 13 to show the relative difference between the depolarization ratios for the SIMONE detection angle and the lidar angle.