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Interactive comment on “Lidar observation of the 2011 Puyehue-Cordón Caulle volcanic aerosols at Lauder, New Zealand” by K. Nakamae et al.

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We thank reviewers for reading our manuscript carefully and for giving useful comments. We extensively revised our manuscript along the reviewer’s comments, and below are our responses to them. Reviewer’s comments are shown in italic and our responses are continued after them. The page and line numbers refer to those published in Atmos. Chem. Phys. Discuss.

Abstract: Line 5-6: As this study seems not the main focus of the paper, it should not be stated here. We deleted it and added a following sentence before the final sentence.

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“The purpose of our study is to quantify the influence of the volcanic ejections from large eruption, and we use the data from the ground-based lidar observation.”

Line 8: The authors should already indicate here that they consider linear depolarization. The total depolarization ratio that we derived from lidar signals was the linear depolarization ratio.

Line 9: Is this the volume or particle depolarization? Yes, it is the volume depolarization ratio

Section1: Page 13466, line 23-24: Give a reference for that statement. We added a reference. : Robock (2000)

Page 13467, line 14-16: The references do not only consider small particles but also large volcanic ash particles. We added the follow sentence in page13467 line14-15. “The ash plumes from volcano were transported to central Europe, and the heights of these ash layers were low enough to deposit on surface after about 6 days from the eruption.”

Page 13467, line 17-19: Give the explosivity index We added the VEI in our manuscript. The VEI of the PCCV eruption in 2011 was about 3. (Dzierma. and Wehrmann, 2012) Additional reference: Dzierma, Y. and Wehrmann H.: On the likelihood of future eruptions in the Chilean Southern Volcanic Zone: interpreting the past century’s eruption record based on statistical analyses, *Andean Geology*, 39, 3, 380-393, doi: 10.5027/andgeoV39n3-a02, 2012.

Section 2: Page 13469, line 14: Give an explanation and reference for the assumed lidar ratio. We added a following sentence. “We assumed the lidar ratio S to be 50 sr at both 532 and 1064 nm in this study from some previous studies (see section 3.3).”

Section 3: The authors assume aerosol free regions at about 30 km altitude and found low R values (about 1.09) in the stratosphere (except in the volcanic aerosol layer) indicating aerosol free regions. However above the volcanic aerosol layer the total

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depolarization ratio (Fig. 1, 4, 6) is about 2%. What is the reason why the total depolarization differs from the molecular depolarization ratio assumed in this aerosol free regions? The value of 0.37 is theoretical value, and has the difference from the measured value which is resulting from the lidar system error. We can estimate this system error using method of Sakai et al. (2003). We calculated about 0.65% of lidar system error. The measured depolarization was about 1.0-1.2% from Fig. 6, and this value was coincided with a fact that when the theoretical value is 0.37 %, the lidar system error is about 0.65%. According to Sakai et al. (2003), this error value is the ratio of the intensity of the perpendicular component to the total intensity of the outgoing laser beam after transmission from the lidar. We added the sentences of “The measured δ was about 1.0-1.2 % at altitudes higher than about 15 km (see Figs. 4 and 6), and this indicates that δ is sum of δ_m (0.37 %) and the lidar system error (about 0.65 %) where there were no aerosols. We estimated δ_p taking into according of this lidar system error (Sakai et al., 2003). When R is close to 1.0, δ_p has a lager error. For example, when R=1.05 and $\delta_p=8$ %, the error of δ_p is larger than 20 %.” in the section 3.2.

The particle depolarization ratio shows no constant value in the volcanic aerosol layer. Do the authors expect vertical variability of the microphysical parameters inside the volcanic aerosol layer (page 13472, line 25-28)? How could that be explained? We could not confirm the descending of aerosol layer from lidar data. The non-uniform particle depolarization ratio shows that the different proportion of non-spherical particles in the volcanic aerosol layer is in each different height. We could not consider the vertical variability of the microphysical parameters inside the volcanic aerosol layer from only the lidar data.

What is the lowest R value for reliable analysis of the particle depolarization ratio? The authors should give a comprehensive error analysis of the retrieved properties, especially of the particle depolarization ratio, to avoid drawing wrong conclusion of the retrieved results. We showed the error of δ_p in each different height in new Fig.6(a). From this figure, we confirmed that the values of δ_p higher than altitude 15 km and

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lower than altitude 8 km ($R \sim 1.0$) have very larger error. (The error of R and δ are sufficiently smaller than that of δp , see right panel.)

Also we show plots in Figures 4(a)-(c) with the error of δp below. We corrected δp and replaced Figs. 4(a) - (c) and Fig. 6(a).

Please also note the supplement to this comment:

<http://www.atmos-chem-phys-discuss.net/14/C6997/2014/acpd-14-C6997-2014-supplement.zip>

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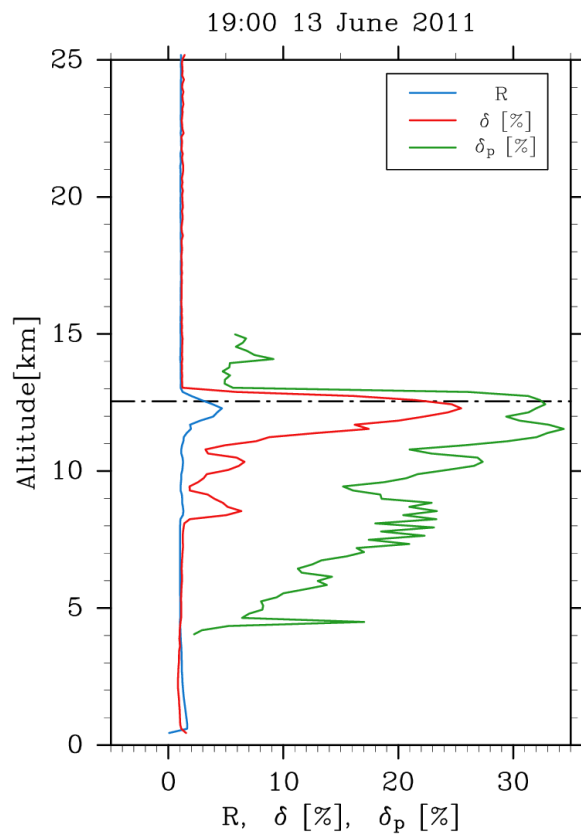
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Fig. 1. Figure6 old

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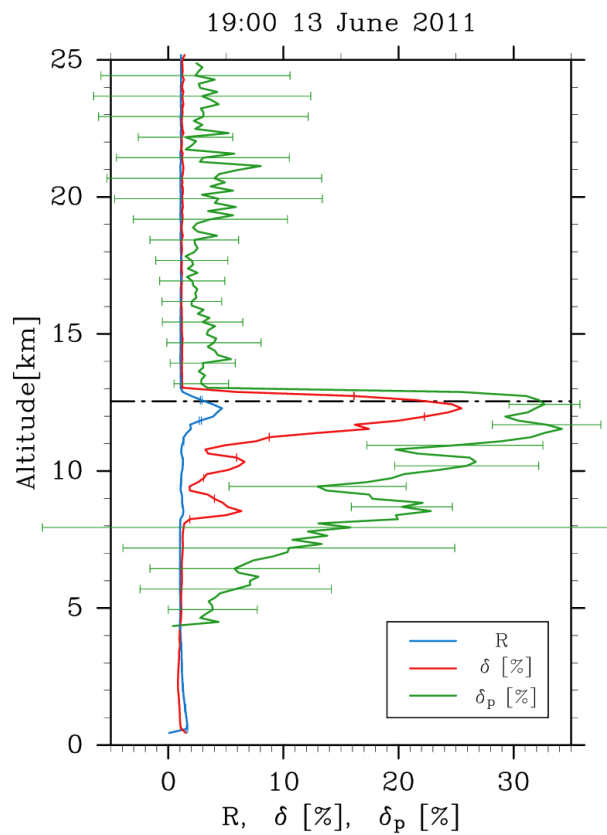
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Fig. 2. Figure6 error bars

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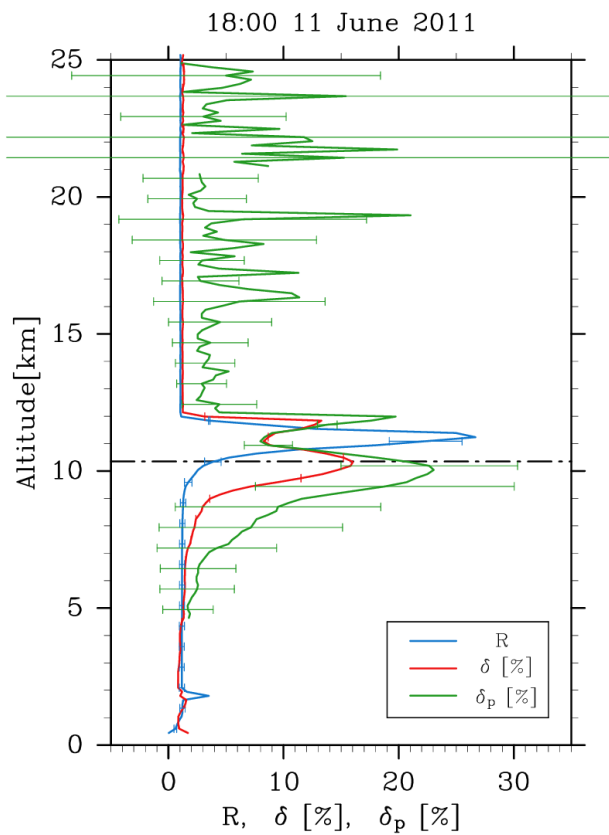
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Fig. 3. Figure 4(a) error bars

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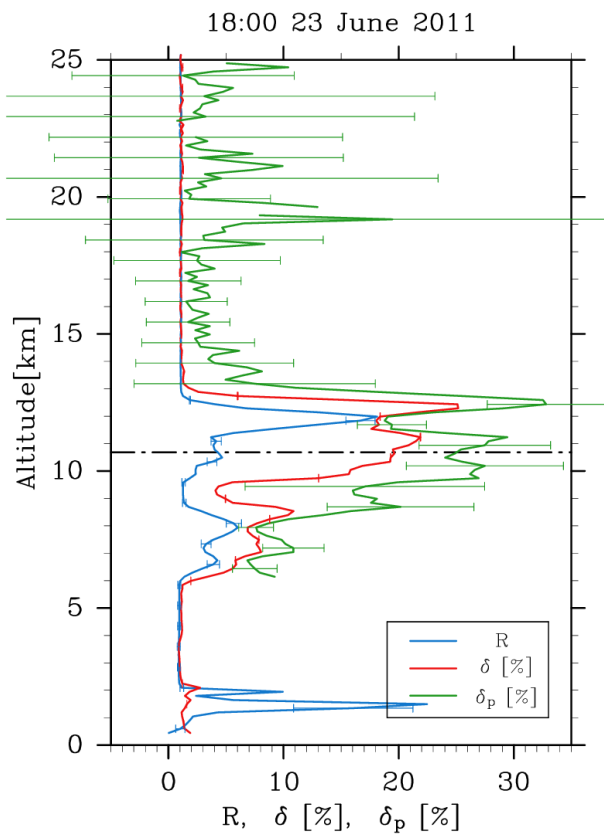
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Fig. 4. Figure 4(b) error bars

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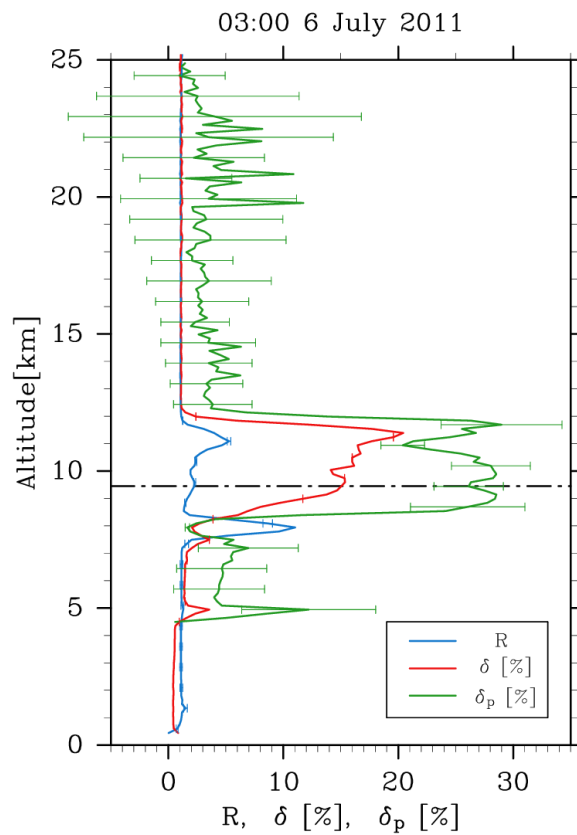
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Fig. 5. Figure 4(c) error bars

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