Interactive comment on "HoloGondel: in-situ cloud observations on a cable car in the Swiss Alps using a holographic imager" by Alexander Beck et al.

Anonymous Referee #2

Received and published: 6 September 2016

We would like to thank the Anonymous Referee #2 for having reviewed this paper and valuable comments and suggestions. We answer each of them hereafter (bold black) and add when needed the modifications in the revised version (bold blue).

0) Totally, the concept of using holography for this application in which the wind speed is low and variable is a good one. The paper is thorough and clearly describes and characterizes the instrument. My only significant scientific criticism is regarding the lack of uncertainty ranges for size-distribution-derived values (number density, diameter, liquid water content) in Figures 7-10. These need to be displayed in the figures so that readers can assess the significance of the observed variability.

Uncertainties were added to figures 7-10 in the revised manuscript. For figures 7-9 the standard error of the mean is plotted. In Figure 10 the standard error for the mean is used for the CDNC and the mean diameter of the liquid droplets and ice crystals. Because of the low ICNC, only around 100 ice particles per interval are measured, which results in a large counting uncertainty. The counting uncertainty is estimated with the Poisson error and is used if it is larger than the standard error of the mean. Consequently the Poisson error is shown in the profile of the ICNC. The error of the LWC and IWC was calculated using error propagation based on the error of the concentration and mean diameter. For the ratio IWC/TWC the error is an estimate for the minimum and maximum values based on the error of the calculated LWC and IWC. Figure captions are updated accordingly.

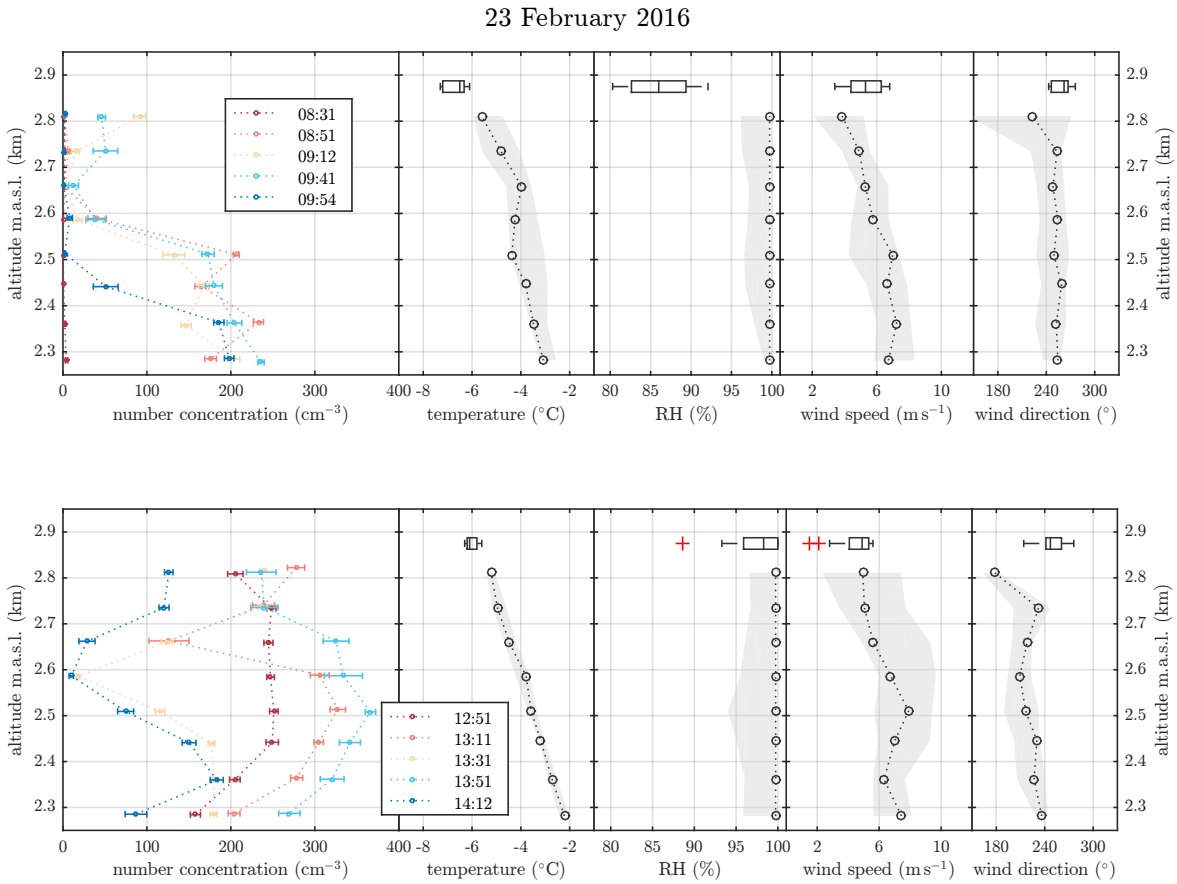

Fig. 7: Height profiles of the Liquid Case measured with the HoloGondel platform during the morning (top) and the afternoon (bottom) of 23 February 2016. The data is averaged over an altitude interval of 75 m. The number concentration of cloud droplets (left panel) shows individual runs of the cable car. The error bars represent the standard error of the mean. For the meteorological parameters (four right panels) the median (circle), the minimum and the maximum (shaded area) values of the vertical intervals are shown. The boxplots indicate the data of the MeteoSwiss station at the Eggishorn about 50 m above the cable car station for comparison. For each box, the central line marks the median value of the measurement and the left and right edges of the box represent 25th and the 75th percentiles respectively. The whiskers extend to minimum and maximum of the data, outliers are marked as red pluses.

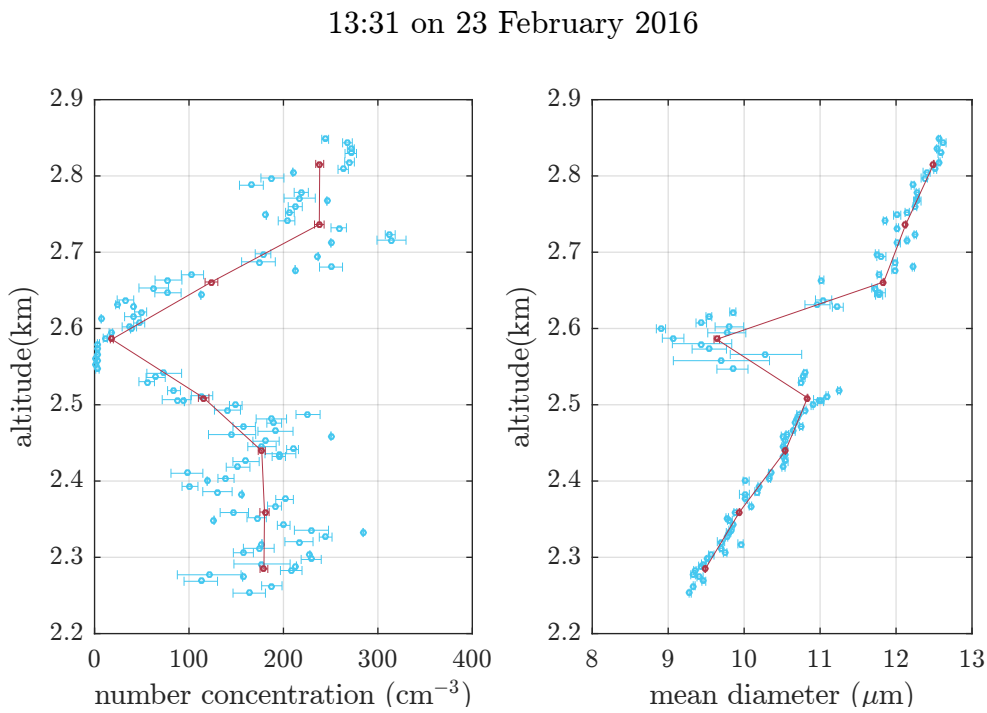

Fig. 8: Height resolved cloud droplet size distribution during the 8:51 run in the morning (left) and the 13:31 run in the afternoon (right). The data was averaged over an altitude interval of 150 m. The error bars represent the standard error of the mean.

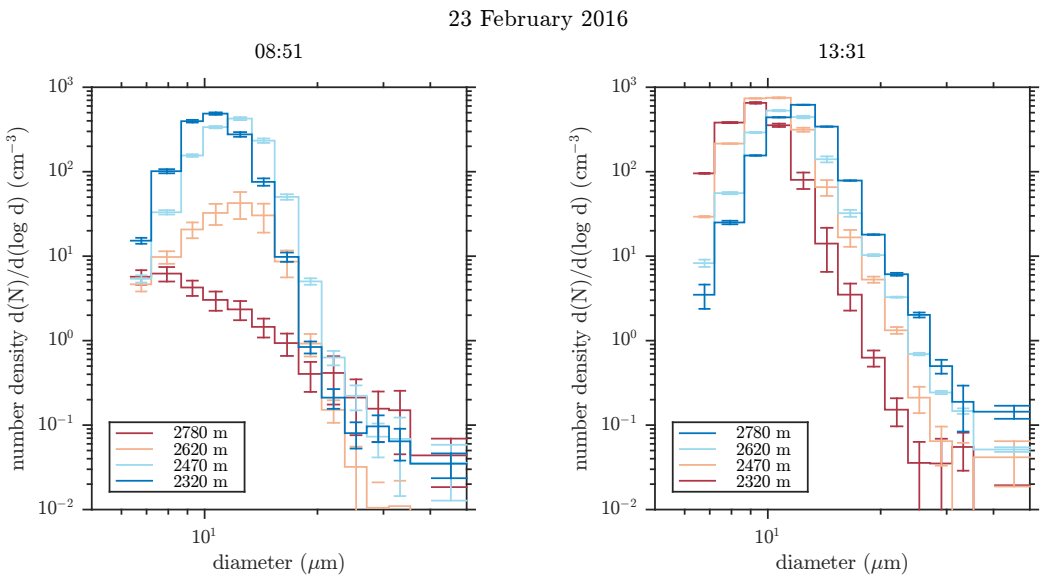

Fig 9: Comparison of two vertical profiles for the cloud droplet number concentration (left) and mean cloud droplet diameter (right) for the run at 13:31 on February 2015. The vertical profiles in blue show the maximal vertical resolution of the HoloGondel platform of 5 m. The vertical profiles in red are averaged over an vertical interval of 75 m. The error bars represent the standard error of the mean.

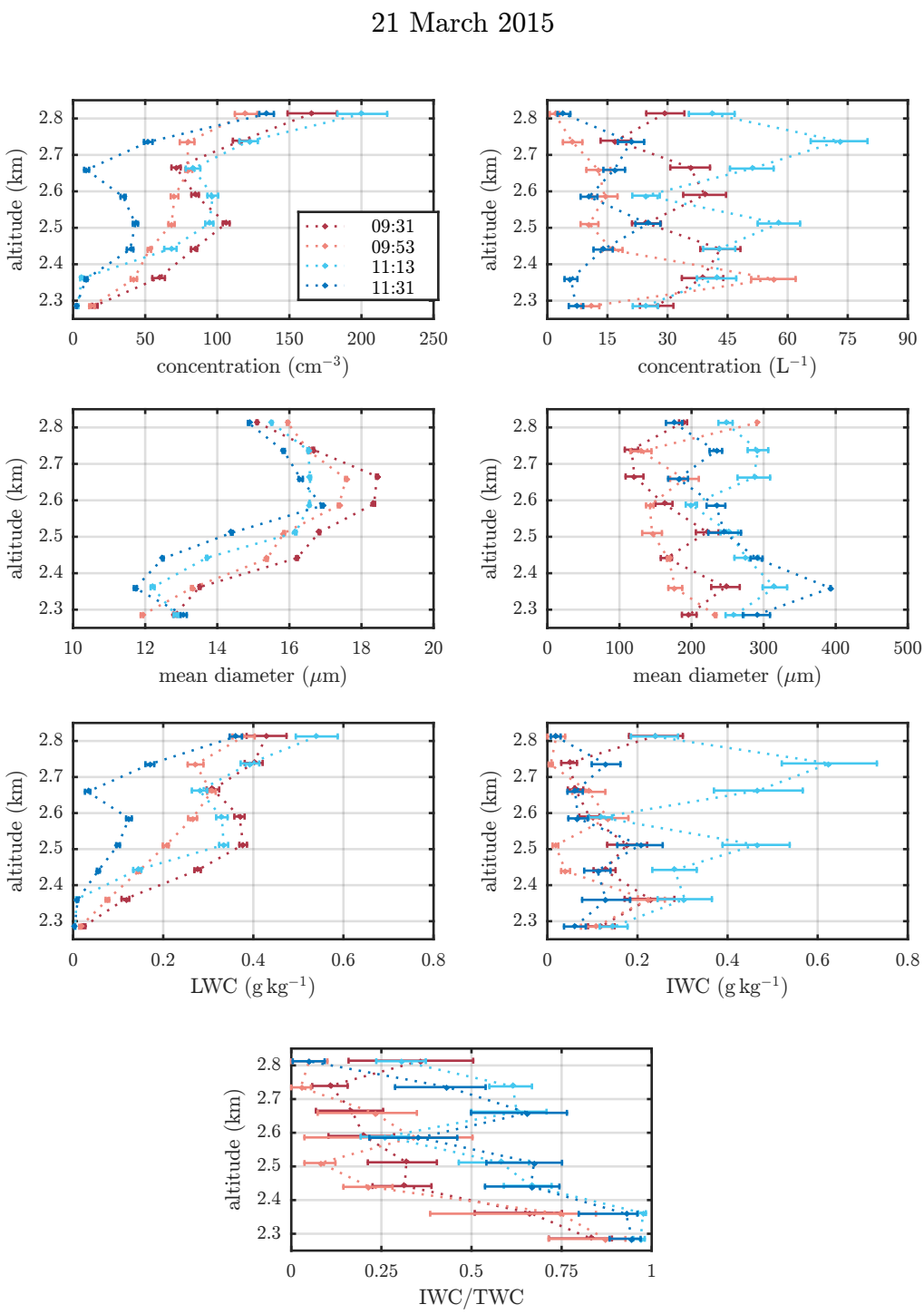

Fig. 10: Height profiles of the cloud droplet and ice crystal number concentration, mean diameter and water content (LWC and IWC) and the ratio of the ice water content to total water content (IWC/TWC) on 21 March 2015. The data is averaged over an altitude interval of 75 m. The error bars represent the standard error of the mean for the CDNC and the cloud droplet and ice crystals mean diameter. Due to the low ICNC the larger Poisson error is shown for the ICNC. For the LWC and the IWC the error was calculated using error propagation based on the error estimate for the particle concentration and mean diameter. For the ratio IWC/TWC the errors represent the minimum and maximum value based on the error for the LWC and IWC.}

There are several other questions stated as follows:

1) Did authors simulate the flow field through HoloGondel or the open path configuration in-between the two towers? This helps to understand the possible ice shattering and distortion of the cloud particle distribution influenced by two towers. Flow distortion may be especially significant when the wind arrives at the instrument obliquely and is therefore influenced directly by the arms.

The flow field around the towers of the HoloGondel platform has not yet been simulated and the authors are aware of possible ice shattering and distortion of the cloud particle distribution. However, we are convinced that these have only little effect on the HoloGondel results:

The travelling velocity of a cable car is on the order of 10 ms^{-1}. At high wind speeds (beyond 10 ms^{-1} at the Eggishorn) the cable car has to stop operation. If the wind direction is opposite to the travelling direction of the cable car the maximal inflow velocity is 20 ms^{-1}. This is much lower than the travelling velocity of an aircraft (on the order of 100 ms^{-1}) and reduces possible ice shattering. For the CIP instrument at Storm Peak Laboratory the increase in concentration due to shattering was less than 10% for wind speeds smaller than 20 ms^{-1} (from personal communication with Robert David).

Low inflow angles reduce the flow distortions by the towers. As the orientation of the towers is fixed, the wind can arrive obliquely to the instrument. A wind speed perpendicular to the travelling direction of the cable car of 10 ms^{-1} was the worst case observed, leading to an inflow angle of 45°. To prevent an influence by flow distortion, the first centimeter of the sample volume outside the window on the camera side is excluded from the data analysis (we included this information in the revised version of the manuscript). For a further analysis of the spatial distribution of the particles in a subsequent paper the distance excluded from the analysis can be increased.

p. 6 line 19: To prevent an influence due to flow distortion if the wind arrives obliquely to HoloGondel the first centimeter of the sample volume outside the window of the camera side is excluded from the analysis. With a cross sectional area of 20 mm x 13.4 mm and an effective depth of 65 mm the corresponding sample volume is 17 cm^3.

2) Can the direction in-between the two towers be adjusted perpendicular to the direction of wind to avoid wind blowing on the windows of tips? This could prevent the shattering of ice crystals.

No, the direction of the towers is fixed. More details about the shattering on the HoloGondel platform is included in the reply to comment 1.

3) It is better to provide readers hologram image samples showing the cloud droplets and ice crystals. For example, show the mixed-phase cloud holographic reconstructed images. This helps readers visually see the mixed-phase cloud particle samples.

We agree with the reviewers comment and would like to refer to figure 11 in the manuscript. In this figure examples of the reconstructed images for cloud droplets and ice crystals are already shown.

4) In page 1 line 5, " Based on a two dimensional shadow-graph the phase resolved micro-physical cloud parameters.....", typically, the shadow-graph is a different technique from holographic reconstructed image. Also see page 5 line 20 " The result is a set of two dimensional shadow-graphs, which are ...". I recommend to remove the word "shadow-graph" since it implies an imaging method that does not involve coherent light.

The word shadow-graph is replaced by the word "image" in the revised manuscript.

5) In page 3 line 30, “If this weight reduction leads to a reduced number of admissible passengers, “ could be “If this weight leads to a reduced number of admissible passengers,”

The authors changed the sentence according to the comment.

6) Page 7, line 20: I’ve never heard it called a "high resolution target"... just a "resolution target" or "resolution chart".

The authors changed the name in the revised manuscript to “resolution target”.

7) Equation 4: As typeset it appears that N and A are two variables... better to have them adjacent so they are clearly identified as numerical aperture.

The N and A are adjacent in the revised manuscript. It has been changed in the equations (2), (3) and (4).

Notes:

It is not a scientific statement, and in the end is up to the judgement of the authors, but I several times asked myself whether Dr. Fugal should be a coauthor on this paper. I don’t know in detail, but my sense is that he may have contributed at a level that would warrant this recognition. I’m sure the authors have asked, but maybe it is worth offering again?

We offered Dr. Fugal to be a coauthor and included him as a coauthor on the revised manuscript.