Comment to Referee#1 19 June 2022

We thank the Referee for helpful advice regarding manuscript acp2022-255: ***Process-based microphysical characterization of a strong mid-latitude convective system using aircraft in situ cloud measurements.***

The manuscript presents a case study of in situ cloud measurements within a European mid-latitude convective system or system cluster, which covered almost the entire Alpine region. The meteorological situation leading to such an extended cluster of deep convection is not frequent and the opportunity to perform measurements with cloud probes aboard a research aircraft is unique in this context. In situ measurements at altitudes between 2 and 12 km in an Alpine convective cluster require an aircraft, suited to fly in turbulent conditions and to avoid icing, that is why airborne in situ measurements with research aircraft like HALO are a challenge. This also points to the importance of this study. In order to sharpen the validity of this study the authors will pinpoint the geographic region it is related to, without generalizing it to mid-latitude convective Systems.

We thank the referee for suggestions to include further analyses and plots directly relating vertical velocities to particle size distributions and discuss the humidity. We see the importance of these correlations and will include them in the revised version of the manuscript. Nevertheless, we want to draw the referee's attention to several sections and figures in the manuscript, where some important and requested data is already shown. E.g. Fig. 10 shows time series of vertical velocities in each flight segment and the results are discussed in the text. In the analysis of microphysical quantities, LWC and IWC are related to other properties, such as MVD and Nc (Fig. 8). LWC and IWC are derived directly from particle size distributions using existing relations, and therefore are consistent within the other microphysical cloud data sets. Afchine et al., 2018, show that the use of cloud data from under wing stations is less prone to particle enhancements occurring around the fuselage of the aircraft. Hotwires or Nevzorov probes were not available in wing stations in the current HALO instrumentation.
Also, a time series of relative humidity over ice and water is presented in Fig. 9 and is the subject of discussion in Sections 2.4 and 2.5. We nevertheless will elaborate more on these topics and include relevant plots or information, as suggested.
Contrary to the referee's comment, cloud particle images from the Optical Array Probe CIP are included in Figs. 11, 12 and 13 and, together with the presented particle size distributions, support conclusions to be drawn about the identified cloud processes.

We take the referee's hint in pointing towards in this study measured maximum vertical velocities of 4 ms^{-1}, in the light of a range of literature stating maximum velocities of 20 ms^{-1}, to further emphasize in the manuscript that the cited vertical velocity was measured aboard an aircraft. These are not to be confused with measured maximum vertical velocities encountered at the center of updraft cores using e.g. remote sensing methods. Without the awareness towards the different inherent measurement methods, capabilities, regimes and peculiarities, there is the risk to misinterpret the different measurements. The vertical velocities measured on the aircraft are amongst the highest measured on different research aircraft in the comprehensive in-situ cloud climatology from Krämer et al., (2017).

We thank the referee for drawing our attention towards Giangrande et al. (2013) (https://journals.ametsoc.org/view/journals/apme/52/10/jamc-d-12-0185.1.xml), which will be referenced in our next draft. According to Fig. 1 (Giangrande et al., 2013) velocities of 20 ms^{-1} are only reached within the updraft core, whereas over large parts vertical velocities remain below 4 ms^{-1}.

Also, Fig. 3 in Giangrande supports this conclusion. Again, one has to be aware that the underlying data set is based on aircraft in situ measurements and not remote sensing or drop sonde measurements. We will also clarify the meteorological situation and the position where the aircraft was flying with respect to convective cores in the manuscript.

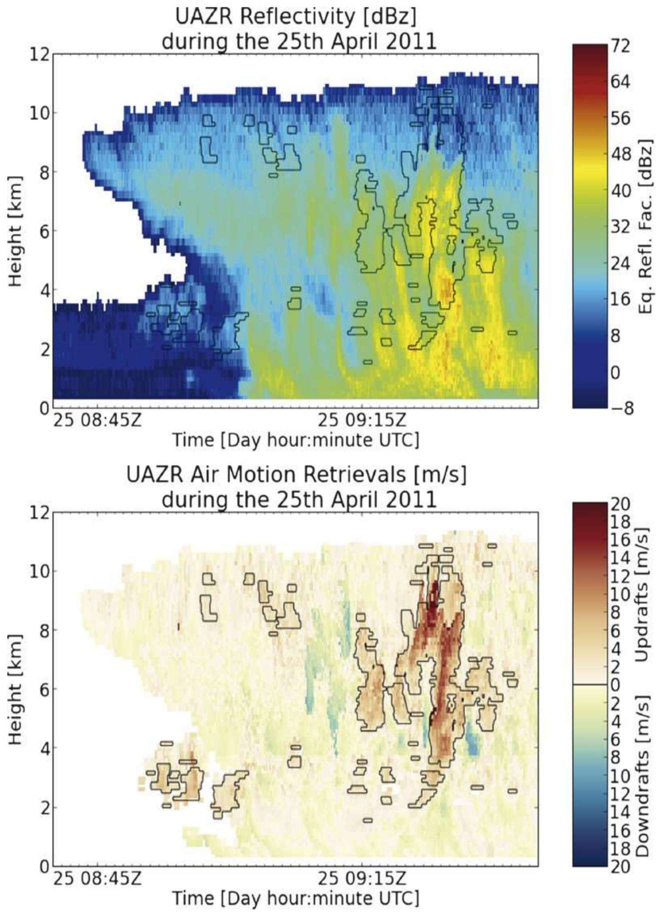

Figure 1 from Giangrande et al.(2013).

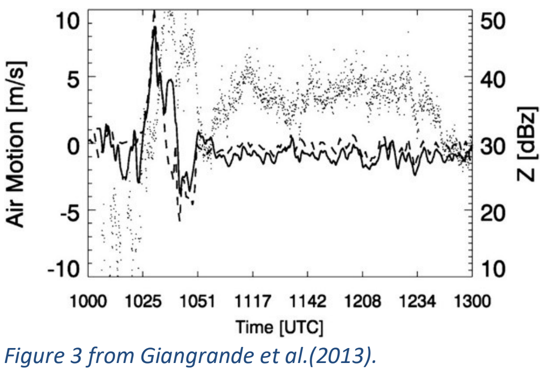

Figure 3 from Giangrande et al.(2013).

Flight regulations under which HALO, a Gulfstream 550, operates are the same as commercial aircraft (EASA CS 25; there is no experimental class in German air law) and such is not a dedicated "storm-hunter" compared to a rugged P3 Orion or Hercules (used in the US). Thus, flights in known icing conditions, as well as flights outside the general g-load envelope are prohibited, just to mention two relevant limitations.

All in all, in situ measurements of cloud microphysical properties have been performed at high updraft speeds (but not at the highest vertical velocities, for reasons of flight control and safety), in a strong Alpine convective cluster system that in its magnitude and size is infrequent to this region in Europe. The presented analysis is a case study, based on a unique data set. Our study identifies and analyses cloud processes under these special meteorological conditions in an extended convective cluster. It further can serve as a unique reference data set calling for process model studies and intercomparisons to different measurement methods. One future goal is the evaluation of remote sensing methods e.g. polarimetric radars with respect to dedicated cloud properties. As such we believe that this study adds value and is of relevance for the scientific community.