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Aggregation in the Dendritic Growth Zone: A statistical analysis combining multi-frequency Doppler and polarimetric Doppler cloud radar observations

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In recent years the dendritic growth zone (DGZ, between -20 and -10°C) has gained a lot of attention. It plays a significant role in the production of precipitation since the ice particle size and number concentration increase significantly in the DGZ. Previous studies have found layers of intense aggregation in the DGZ. Polarimetric radar measurements have revealed that these layers of enhanced aggregation are often accompanied by layers of enhanced differential radar reflectivity (ZDR) and specific differential phase shift (KDP). These observations suggest the growth and increase of concentration of oblate ice crystals at the same height where aggregation is enhanced. Analysis of radar Doppler spectra and mean Doppler velocity (MDV) have further shown a secondary, slow falling peak accompanied by a slow down in the MDV at the same height as the layers of enhanced aggregation and growth of ice particles. From previous studies it is unclear and often case study dependent where this increase in number concentration of small ice crystals originates and whether it is connected to the enhanced aggregation in the DGZ.

We present a statistical analysis of DGZ observations collected during a three-month-long winter campaign in Jülich, Germany. For our analysis we use observations from a polarimetric W-band Doppler radar and zenith pointing X-, Ka- and W-Band Doppler radars. This unique setup allows us to simultaneously look at the aggregate size, as well as ice crystal shape and concentration. We can therefore look at the described increase of aggregation and ice crystal size and concentration in more detail and see if these signatures can be found in general in mid-latitude clouds.

Similar to previous studies, our statistical analysis shows a strong increase of aggregation within the DGZ. This increase in aggregation is correlated to a slow down in MDV just below -15°C. The larger the particles in the DGZ, the larger is also the slow down of the MDV. The strong temperature dependence of the slow down and an analysis of the Doppler spectra allowed us to narrow down the origin to an increase in the concentration of small ice crystals in this region as well as enhanced depositional growth leading to a buoyancy effect. Due to the Doppler capabilities of our polarimetric W-band radar, we can derive the maximum of spectral ZDR (sZDRmax), which is not affected by the low ZDR of aggregates. sZDRmax starts to increase at just above -15°C, showing an increase in size of ice crystals at this height. Interestingly, sZDRmax stays constantly elevated until -4°C. KDP shows that the concentration of ice crystals is continuously increasing in

the DGZ. This is in contrast to the KDP layers found in previous studies, where KDP was enhanced only around -15°C. We also find KDP to stay constantly elevated until -4°C. Given strong aggregation in the DGZ as a sink for small ice crystals, a source for this continuous increase in ice crystal concentration has to be found.