What does a positive $K_{dp}$-peak region above the melting level indicate? 
~ Statistics of $K_{dp}$ profiles obtained by a Ka-band polarimetric radar ~

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A positive $K_{dp}$-peak region above the melting level in a stratiform region associated with the Baiu front was observed by a Ka-band polarimetric radar of Nagoya University during the simultaneous particle sounding observation. Our previous study indicated that the $K_{dp}$-peak region would be attributed to the existence of large number of plate- and/or column-type ice crystals. However, the $K_{dp}$-peak region was observed various height range, not only the dendritic growth layer (DGL, around -15 degree Celsius), but also higher (-5 degree Celsius) and lower (less than -20 degree Celsius) temperature range. And the $K_{dp}$-peak region was also observed in the winter snow clouds above the melting level in both convective and stratiform regions. In this study, we explore statistical properties (thickness, duration time, maximum value) of the $K_{dp}$-peak region obtained in both summer and winter seasons and indicate a hypothesis its formation mechanism.

The $K_{dp}$-peak region is defined by a vertical profile of median of $K_{dp}$ at each level obtained by every 10 min RHI observations. If it has greater than 1.0 deg. km$^{-1}$ above the melting level, we evaluate that the $K_{dp}$-peak region is detected. From May 15 to June 14, 2016, total 40 cases of the region are detected and almost all cases locate around convective precipitation regions detected by a JMA radar. It has a deep thickness (7-12 km) and maximum $K_{dp}$ reaches 5.7 deg. km$^{-1}$ near the convective region. It is thinner (5.5-7.5 km) and maximum $K_{dp}$ has smaller value when it locates in the stratiform region far from the convective one. Time-height section of the median of $K_{dp}$ shows the duration time existing the $K_{dp}$-peak region is 1-2 hours and the descending of $K_{dp}$-peak for 2 km in 1 hour in several observed cases. On the other hand, only a few cases of the $K_{dp}$-peak region are detected in the winter snow clouds observed in the Hokuriku District, Japan. Although maximum $K_{dp}$ values in the convective and stratiform regions are same as those in the Baiu season, the $K_{dp}$-peak region is thinner and almost its duration time is lesser than 1 hour.

As a result, the observed positive $K_{dp}$-peak region should be attributed to the existence of large number of ice crystals formed in the upper level (from -15 to -40 degree Celsius) in the convective region. This large concentration region of ice crystals advects to the stratiform region with descending. In the stratiform region, depositional heating in the $K_{dp}$-peak region should form weak updraft, thus it is expected to cancel the fall speed of growing ice crystals and the height of the $K_{dp}$-peak region is sustained. Shorter duration time of the existence of the $K_{dp}$-peak region in the winter season should be attributed to the lesser horizontal scale of the stratiform precipitation region. Using the Ka-band polarimetric radar, we can observe the existence of high density region of ice crystals and its advection in a mesoscale convective system. If we can detect it using an X-band phased-array polarimetric radar recently installed in Japan, we may expect the dense ice crystal and following aggregation areas above the melting level, and little increasing rainfall area at the surface.

Keywords: Ka-band polarimetric radar, specific differential phase (KDP), ice crystals