Dual-Wavelength Polarimetric Radars Observation of Snow Development Process

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Current observations of natural clouds and snowfall are still inadequate, which leads to challenges to numerical model that predict the state of the cloud and snowfall. We should improve our observations to better understand the cloud and snowfall processes.

X-band radar has an operating frequency of 8-12 GHz, a short wavelength and a high sensitivity, and can be used to detect smaller water droplets as well as some ice phase particles. Ka-band radar has an operating frequency of 35GHz that is adjacent to X-band radar frequency in weather radars, but the sensitivity is higher than X-band radar so the majority of ice particles can be observed, and some cloud droplets can also be observed. Existing studies have shown that the combination of an X-band radar and a Ka-band radar is the best choice for observing weak precipitation (Marielle Gosset and Henti Sauvageot, 1992), which can be used for complete study of in-cloud processes, identification of supercooled water, estimation of condensate size, shape and other characteristics and so on.

Based on the ability of X-band radar to observe weak rainfall and snowfall, the ability of Ka-band radar to observe snowfall and clouds, and the advantages of using the dual-frequency radars, this study will combine X and Ka-band polarimetric radars for observation and analysis of the snowfall development process.

Snowfall occurred in Beijing on February 14th this year, we used dual-frequency polarimetric radars to carry out tracking and synchronous observation of the snowfall process. According to the different stages of snowfall, different observation methods have been used to obtain high time-resolution and targeted data. In detail, when the snow cloud is far, the X-band radar carries out a PPI-scan, and the Ka-band radar carries on a vertical scan, tracking the cloud movement direction and determining the elevation angle and azimuth range required for the RHI scan of cloud body. When snowfall begins, X and Ka-band radars simultaneously carried out an RHI-scan, obtaining a vertical structure of snowfall clouds and snowfall. In this period, a PPI-scan for X, a vertical-scan for Ka and an RHI-scan for X, a vertical-scan for Ka are also carried out for supplement to obtain the horizontal structure, vertical velocity changes and other characteristics of cloud and snowfall. About 11 hours of data are obtained in total.

Then the macroscopic and microscopic characteristics of the snowfall development process are analyzed by using the single-frequency polarized radar variables and the dual-frequency polarized radar variables. The results show that when the snowfall begins at about 9:20 (BJT), Ka radar clearly shows that the cloud presents a double-layer structure, The upper cloud height range is about 6.5km-8km, the lower clouds top height is about 5km, and X radar is not able to clearly observe the upper clouds, while the lower cloud top range is incomplete than Ka, revealing that the upper and lower clouds are composed of smaller particles. At this time, the shape of the surface observation snow particles is found to be single spherical particles.

After the snowfall begins, the cloud continued to develop, at around 12:40 (BJT) the double-layer cloud fused to a single-layer cloud, and cloud top height was about 7Km. X radar cloud top is still incomplete

than Ka radar, showing that at this time the top of the cloud is still small particles. Surface observations have found that the shape of the snowfall particles becomes complex, from single spherical particles to aggregated plates, aggregated needles and aggregated columns.

At around 15:50 (BJT), the cloud was transformed from single-layer to double-layer. The upper cloud height range is 4km-5km, lower than that at the beginning of snow. The lower cloud top is about 3.5km, which is also lower than that at the beginning of snowfall. X-band radar still fails to fully observe the upper clouds and the lower cloud tops, which are still small particles. Ground observation found that at this time the snowfall intensity is highest and the shape of the particles are the most complex, single stellar, aggregated stellar, plates and needles can be seen. But single-branched ice crystals are more transparent than the previous ice crystals, indicating that the cloud water vapor conditions were better.

Around 16:40 (BJT), as the cloud weakens, the height of the double-layer clouds continues dropping. The upper cloud range is 2km-3km, and the height of the lower cloud top is about 2km. Ground observation snowfall intensity is reduced, and the shape of snowfall particles becomes simple, including single plates and single spherical particles.

This snowfall process experienced the evolution of double-layer cloud to single-layer cloud to double-layer cloud. Double to single-layer cloud fusion happened when the cloud development is the most exuberant and the shape of snow particles become complex. But the most complex snow particle shape appears when the single-layer cloud separated into the double-layer cloud. Particle shape has undergone single spherical to the aggregated particles to the most complex shape to coexisting of the single-plate, single-spherical evolution process.
This study will further use the data to retrieval the vertical velocity in the cloud and the size and shape of clouds and snowfall particles to fully analyze the cloud-snowfall development process.

Keywords: Dual-Wavelength, Polarimetric Radar, Snow, Scattering

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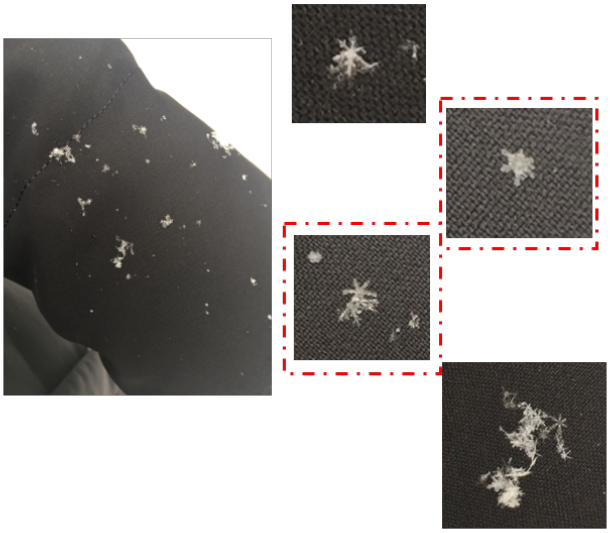

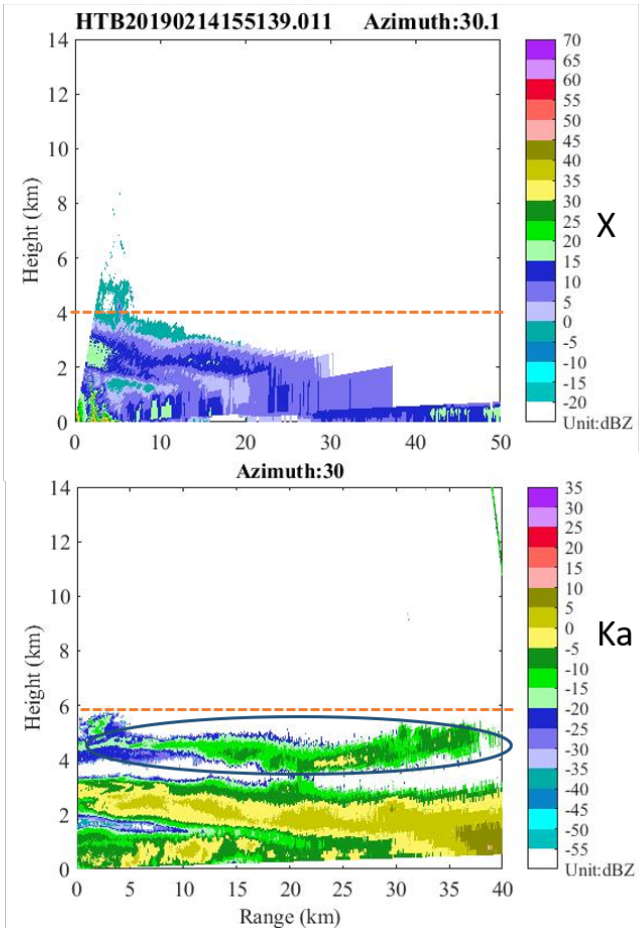
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