Clouds Observations with High Resolution W-band Doppler Radar FALCON-A at Ny-Alesund

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Clouds are one of the most significant items in climate system and would have important role on global warming. Especially in the arctic region, investigations of characteristics and behavior of clouds are important because arctic warming is accelerated in recent decades.

Observation of clouds with radars in millimeter wave range is one of the most powerful methods to derive information on interior of clouds. We have developed a cloud profiling FMCW (Frequency Modulated Continuous Wave) Doppler radar named FALCON-A (Fig.1) in W-band 94GHz and installed at an Arctic Station in Ny-Alesund, Svalbard, Norway, N79°as a part of the project under GRENE Arctic Climate Change Research Project, JAPAN. It consists of two 1m-diameter antennas and has high spatial resolution of 0.18°FWHM. A high range resolution of 48m is realized with the FMCW type radar, which is about several times higher than that of normal pulse type radars. FALCON-A has enough sensitivities to observe thin clouds at high altitude and has high resolution in Doppler measurements. Performances of FALCON-A are summarized in Table 1.

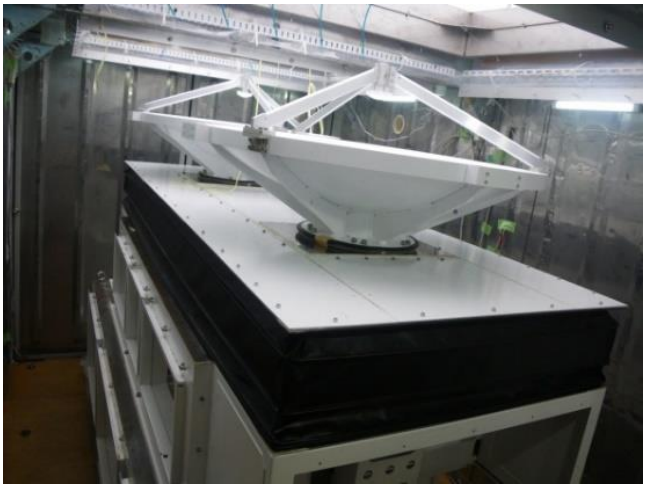


Fig.1. Cloud Profiling Doppler Radar FALCON-A at Ny-Alesund, Svalbard, at N79°in arctic region..

Antenna Diameter	1 m × 2
Frequency	94.84 GHz
Output Power	1W (+30 dBm)
Beam Width	0.18 deg.(FWHM) = 15m at h=5km
Range Resolution	48 m (Typ.)
Direction of Antennas	Zenith
Polarization	1 Linear
Doppler Velocity Range	±3.2 m/sec (Typ.)
Time Resolution	10 sec (Typ.)

Table 1.. Parameters and Performances of FALCON-A

Using FALCON-A, we started regular observations in 2013 September at Ny-Alesund even in the winter seasons. Fig.2 shows observed cirrocumuli on 2013 Sept. 16 at around 4 to 6 km in height, which consist of two layer. Upper layer of cirrocumuli having the thickness of around 1 km is quite stable and horizontal size is estimated to be similar to the height thickness. Lower layer whose size is around 1.5 km, contrary, has defuse structures and are falling down with 2-3 m/s. Lower layer would be larger snow particles produced in the upper cirrocumuli structures.

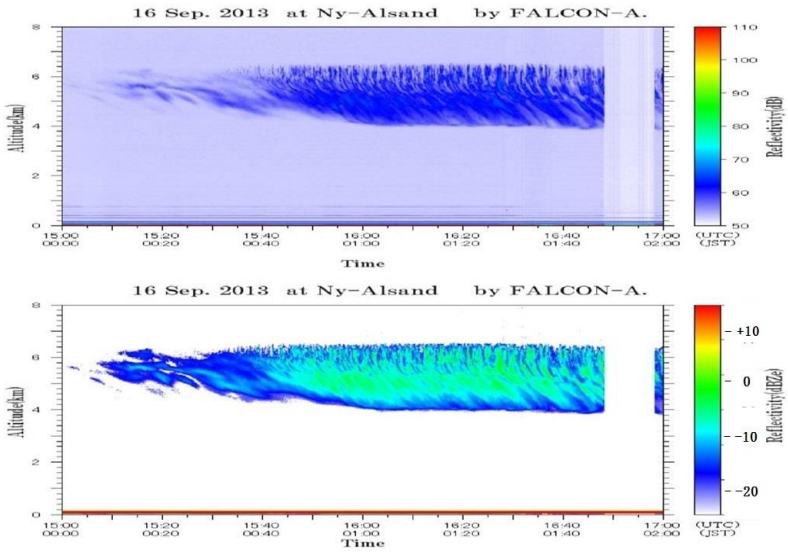


Fig.2. Example of cirrocumuli observations with FALCON-A on 2013 Sept. 16th in Svalbard.
Left panel is a photograph of the cirrocumuli, right panels show intensity of echo, and radar reflectivity factor. Two layers are seen, upper layer from 5.5 to 6.5 km in height has granular structure, contrary, lower layer form 4 to 5.5 km shows diffuse structure with biased trajectory which means falling.

Fig.3 shows an example of Doppler observations of Clouds obtained in 2014 Dec. 11th. Precise interior motions of clouds can be seen with Doppler maps. These results are quite useful to investigate characteristics of clouds in various cases in arctic region and would be useful for investigations of climate change and global warming occurring in arctic region.

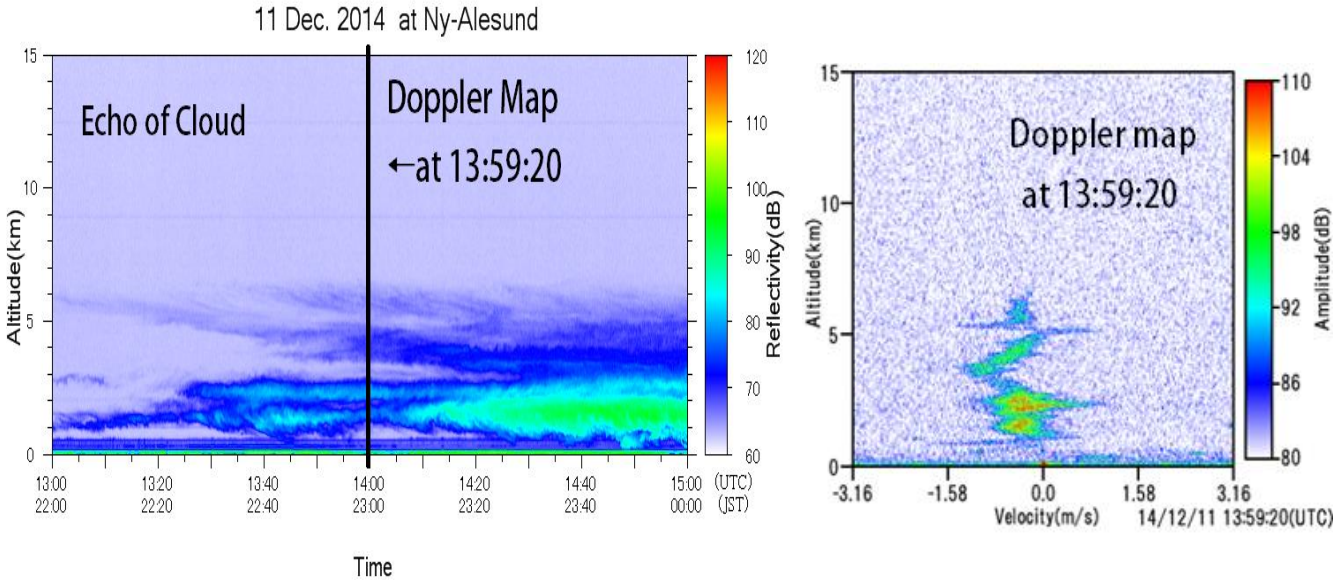
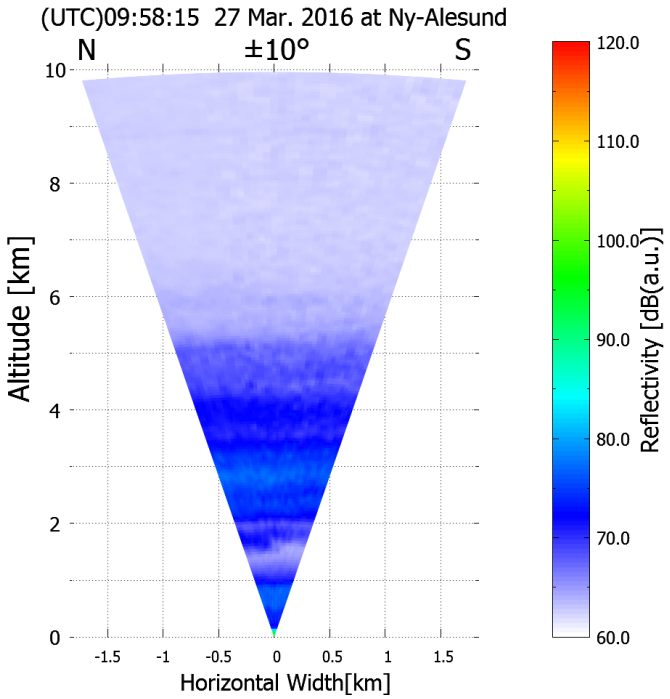


Fig.3. Time-Height map of echo of cloud (left panel) and Doppler map (right panel) at 13:59:20 on 2014 Dec. 11th There are three layer of clouds; lower cloud at h=1-3 km, middle layer around 4-5 km, and upper layer at 5-6 km. Between the upper and the middle layer cloud around the height of 5 km, strong up/down motions are seen with the Doppler velocity of +/- 1m/s.



FALCON-A has a scanning observation mode to obtain 3D structures of cloud. Width of scanning is +/- 5 ° centered at the zenith. Fig.4 shows an example of scanning observations with FALCON-A on 2016, March, 27th. Inner structure of clouds are seen from the height of 0 – 5 km in Fig.4.

Fig.4. Scanning map of echo of cloud