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Frequency Modulation Continuous Wave Profiler for Precipitation and Observations in Different Regions of China during 2013~2016

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➢ C band FMCW Profiler System

Understanding higher temporal and spatial changes in the precipitating clouds drive the development of radar technology. Compared with pulse Doppler radar, frequency modulation continuous wave (FMCW) radar can provide detail characteristics and rapid evolutions of clouds.

Pulse Doppler radar using a narrow pulse transmitting method to improve the detecting resolution, but the bandwidth reduced the sensitivity of receiver. The technology of wide pulse, narrow pulse receiving pulse compression lift the system noise level, the result is affects the detection capability. So the pulse Doppler radar is difficult to obtain higher range resolution without loss of detection ability conditions.

The distance measure of FMCW radar is modulated the transmitted continuous wave signal and demodulated for return signal. The advantage of FMCW radar system is high precision, no blind zone and lower peak power.

LaSW's C band FMCW Profiler(CFMCWP) is mainly used for accurate detection of high vertical resolution in the precipitation cloud. The technology include the bistatic dual antenna system, weighted processing method of the FFT spectrum transform and sidelobe suppression. Table 1 give the main parameters specification. The spatial resolution is 15m-30m and the resolution temporal is 2s-3s ,CFMCWP can obtain the rapid evolution process of cloud and precipitation from 15m to 24km height range.

Table 1. Operating parameters for CFMCWP

Parameter	Specification
Frequency	5530MHz±3MHz/±3.5MHz
Pulse Repetition Period	600、700μs
Band width	6MHz±3MHz/±3.5MHz
Typical sampling time	2s,3s
Range resolution	15m、30m
Height range	15m-15km/15m-12km/ 30m-24km
Detecting ability at 15km	<-20dBZ
Antenna	Bistatic; paraboloid
Antenna radius	1.6m
Antenna gain	≥35dB
Beam width	≤2.6°
Transmitting power	≥150W
Number of FFT	First/Second: 512/512
Number of spectral average	1~10

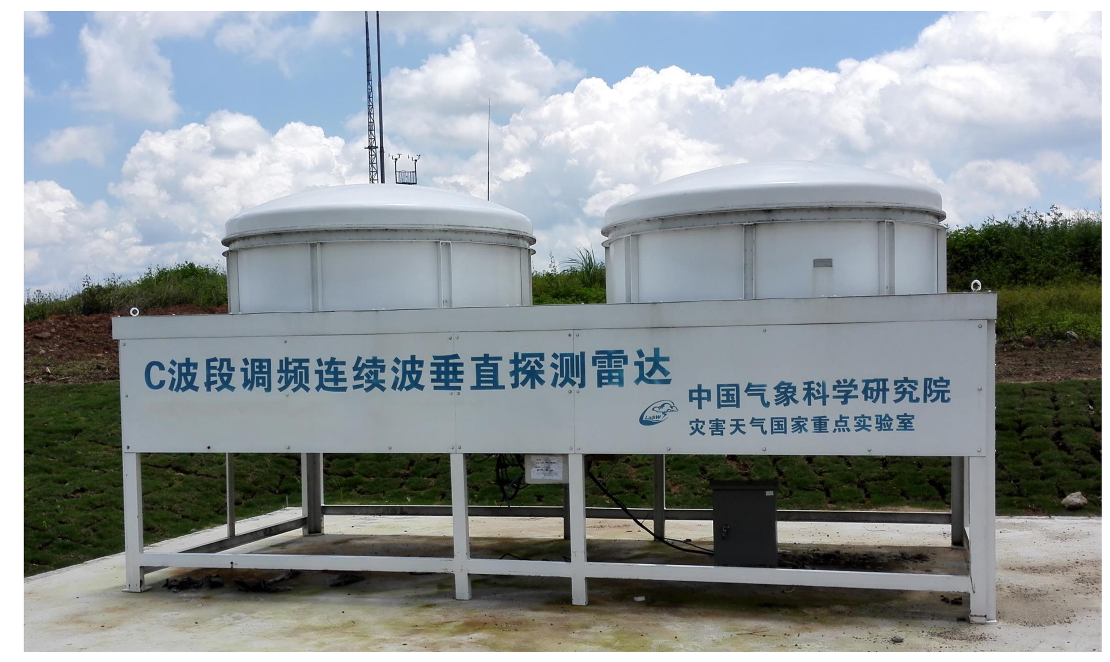

Fig.1 Photo of CFMCWP

➢ CFMCWP observing ability

- **Boundary air turbulence**

The atmospheric refractive index structure constant C_n^2 computed from the Z.

- **Stratiform characteristics**

The bright band height is near 5km. The distribution of Z is broad and the velocity is concentrated, which indicates that different masses of solid particles exit over the melting layer, and the difference of shape and density of particles show the difference of reflectivity, but the change of their fall speed is smaller.

- **Convective cloud**

The small proportion of convective activity in the precipitation cloud. The updraft of air motion is 10m/s. The height of Z_{max} was below BB, the convection was happened in the warm cloud during the June. The height of convection increased in July.

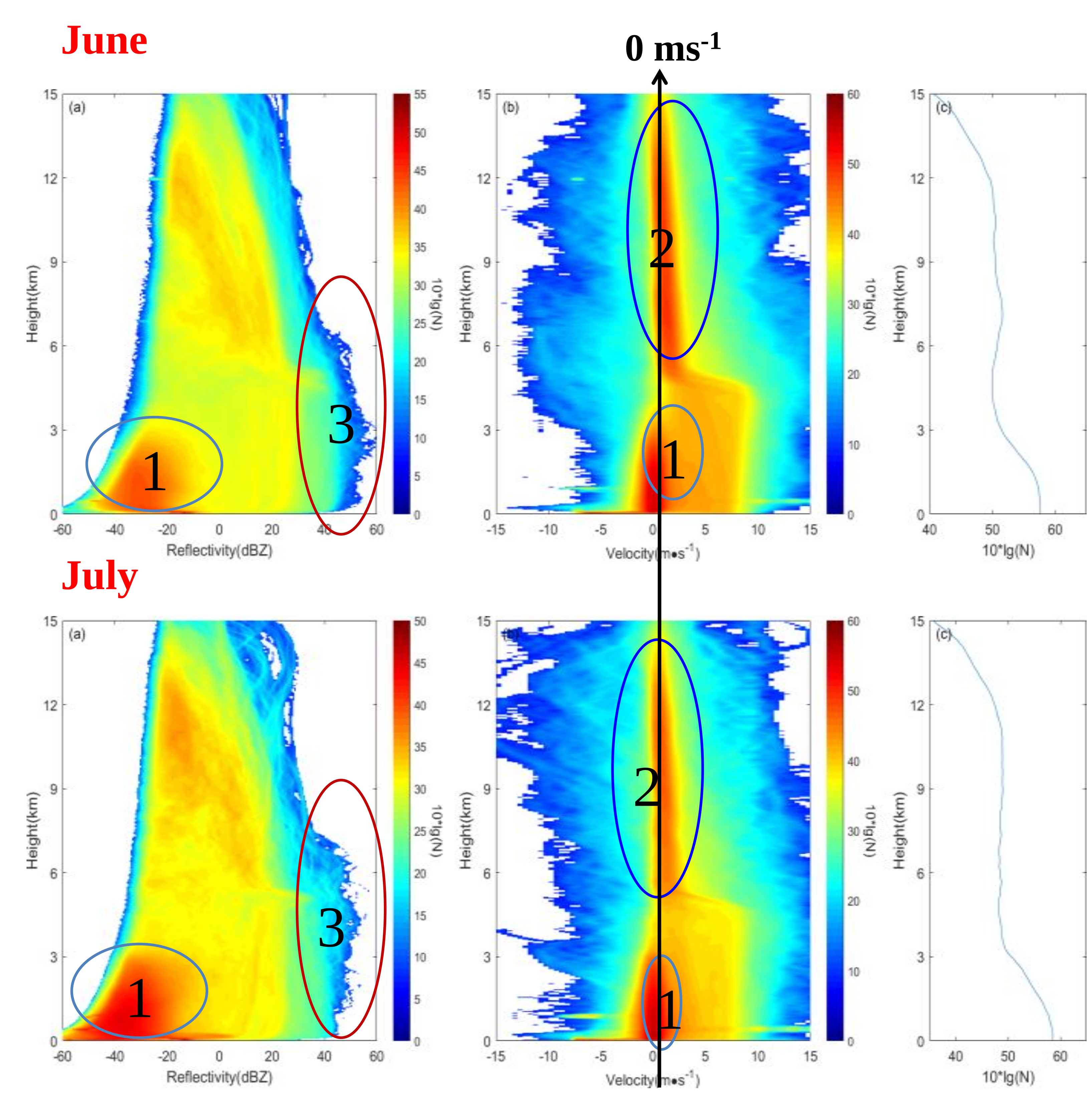

Fig.2 CFADs with the month continue observation of June &July 2016 in South China
(a) Reflectivity (b) Vertical velocity (c) Profiles number

Preliminary analysis of the observations

➢ Strong downdraft at upper level

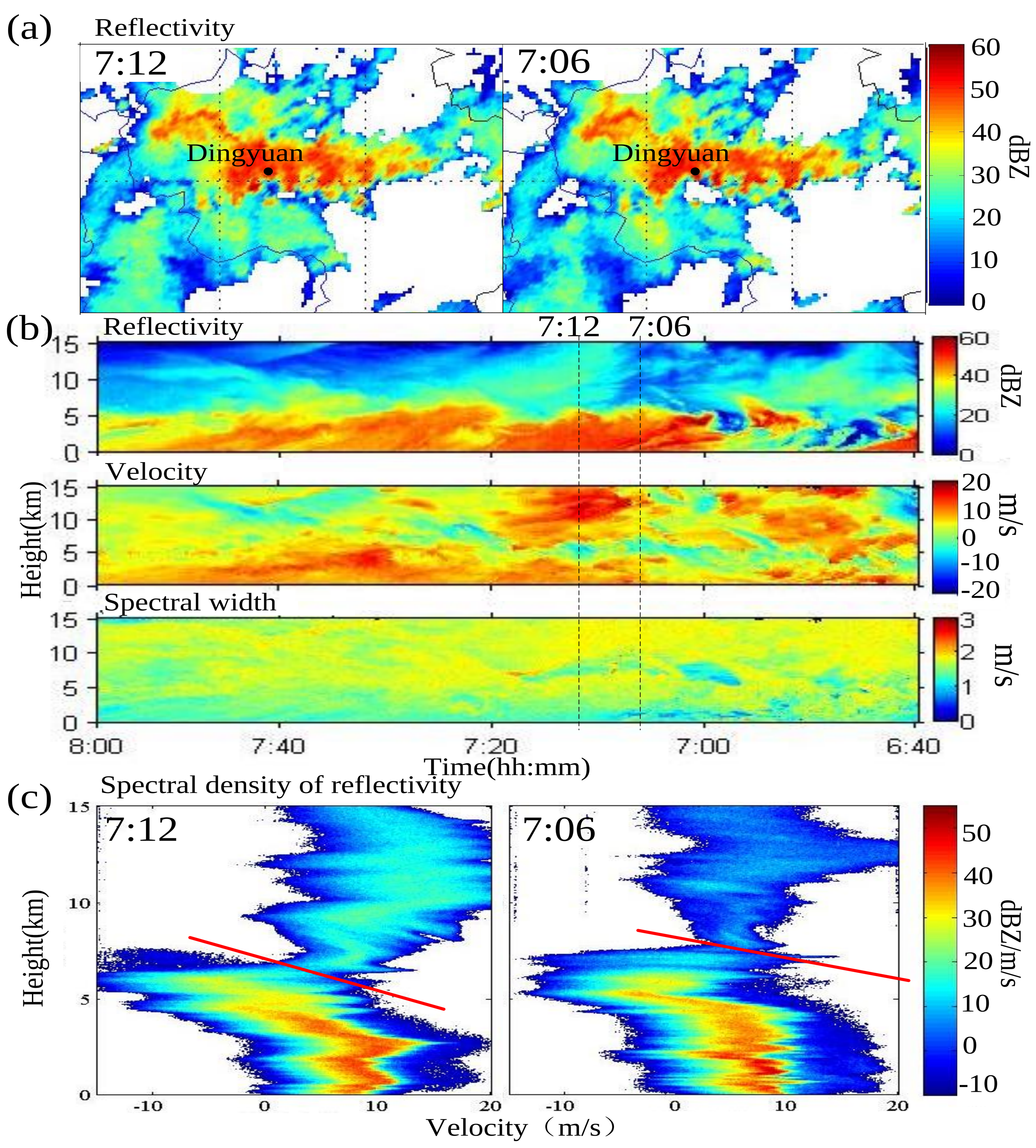

Fig. 3 Precipitation of observed from scanning radar and CFMCWP on Aug.24,2013.

(a) Reflectivity of scanning radar (b)Products of CFMCWP

(c) Spectral density of reflectivity at 07:06 and 07:12

➢ Deep convection on Tibetan plateau(4507m)

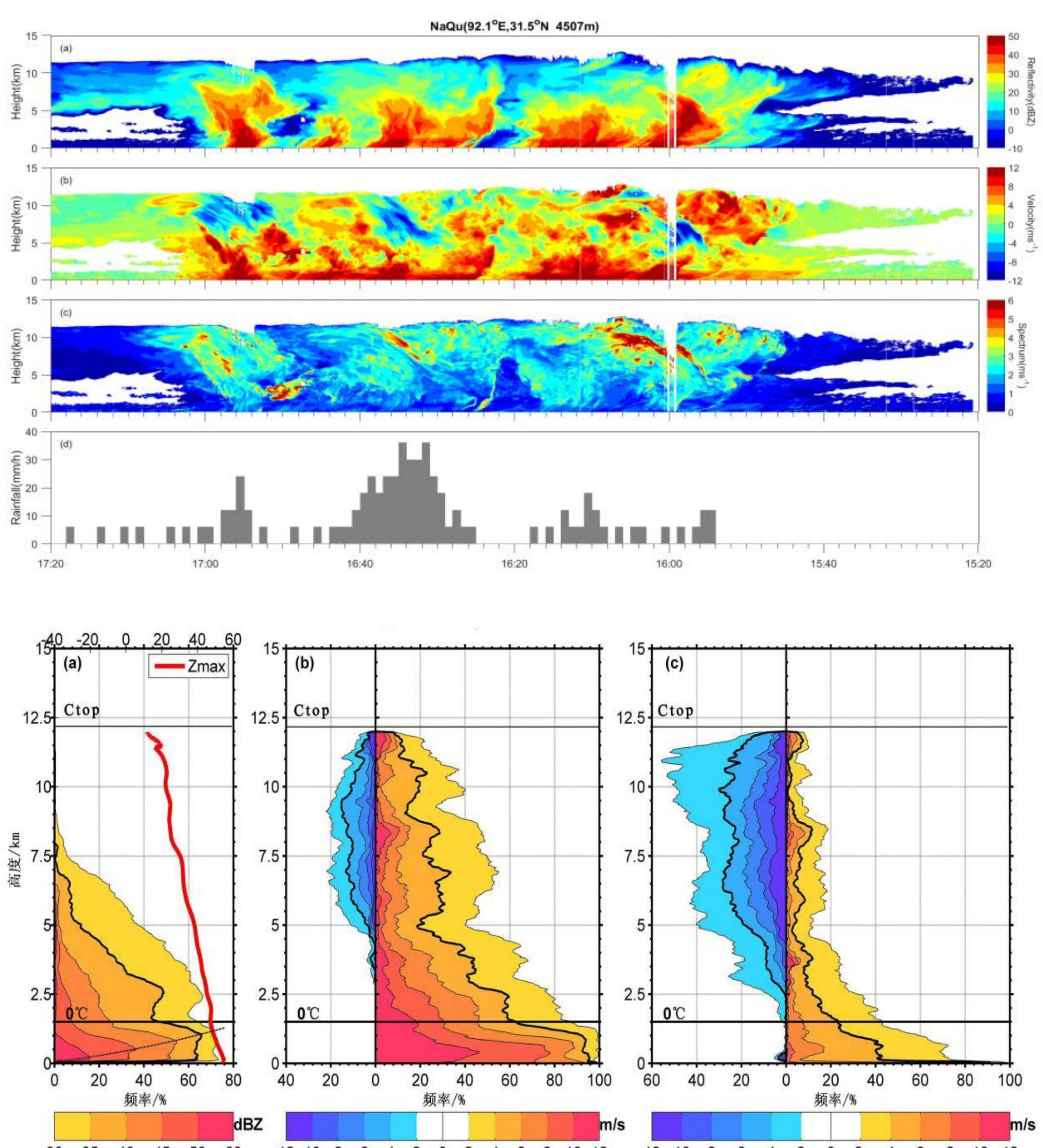

Fig.4

Up: Deep convection in monsoon of Tibetan Plateau Jul.04 2014.

(a) Reflectivity, (b)vertical velocity(Downwards:+, upwards: -),

(c) air motion(same b), (d) rain intensity calculated from minute rainfall.

Down: CFADs （sample number：1200）

(a) reflectivity（black thick line: Z>35dBZ，red line：Zmax

(b) Doppler velocity（black thick line：Vupmax<-4m/s & Vdownmax>4m/s）

(c) air motion（black thick line:Wupmax<-4m/s, Wdownmax> 4m/s）

➢ Mix processes from Spectrum in melting level

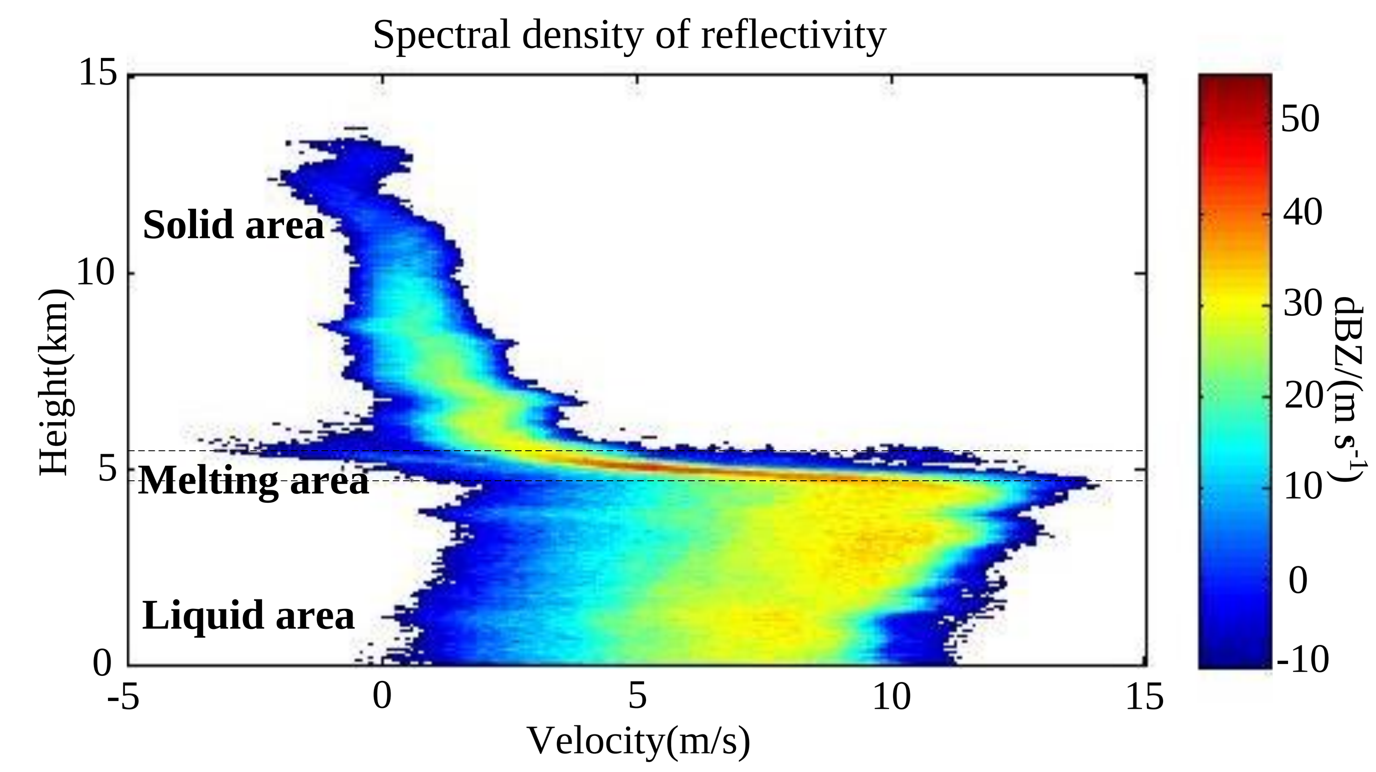

Fig. 5 Spectral density of reflectivity at 21:45:35 UTC on Jul. 4, 2013

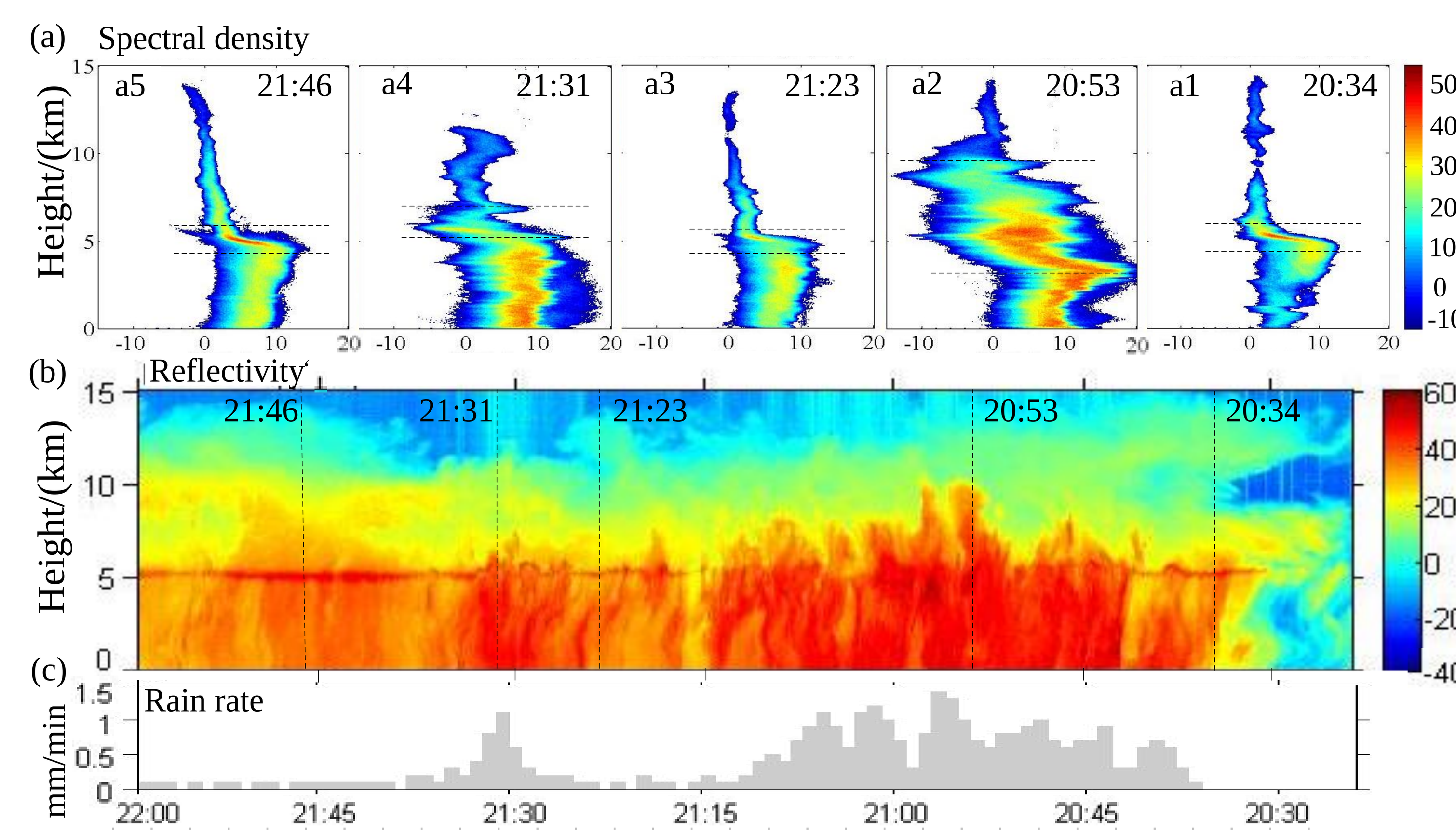

Fig. 6 Products of CFMCW and rain count on Jul. 4, 2013,Meiyu season

(a)spectral density of reflectivity (b) reflectivity (c) rain count of minute

➢ Air turbulence in boundary layer

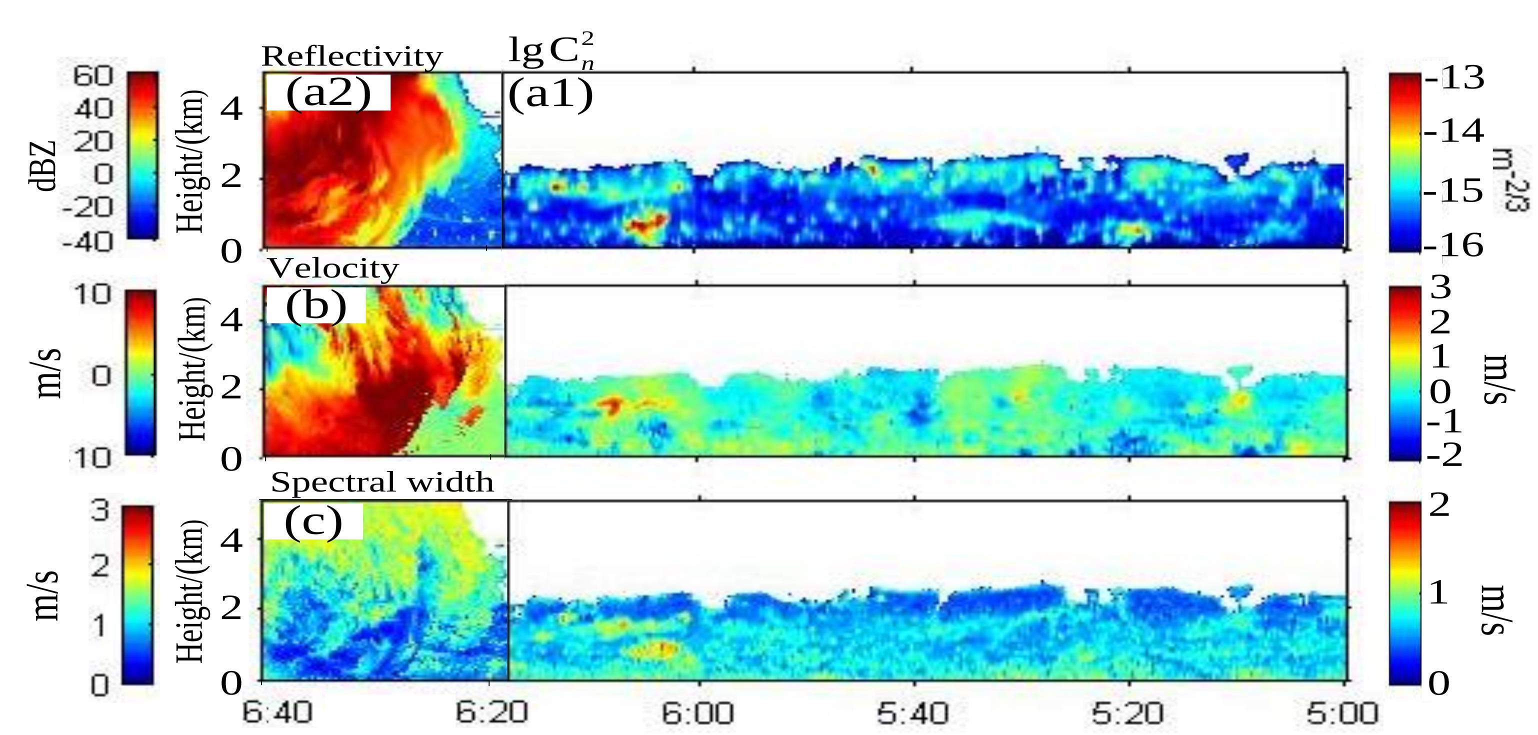

Fig.7 Time-height section of CFMCWP products during the clear air and precipitation at 05:00-06:40 on Aug.24,2013,Meiyu season

(a1)Reflectivity (a2)Refractive index structure constant C_n^2

(b)Vertical velocity (c) Speed width

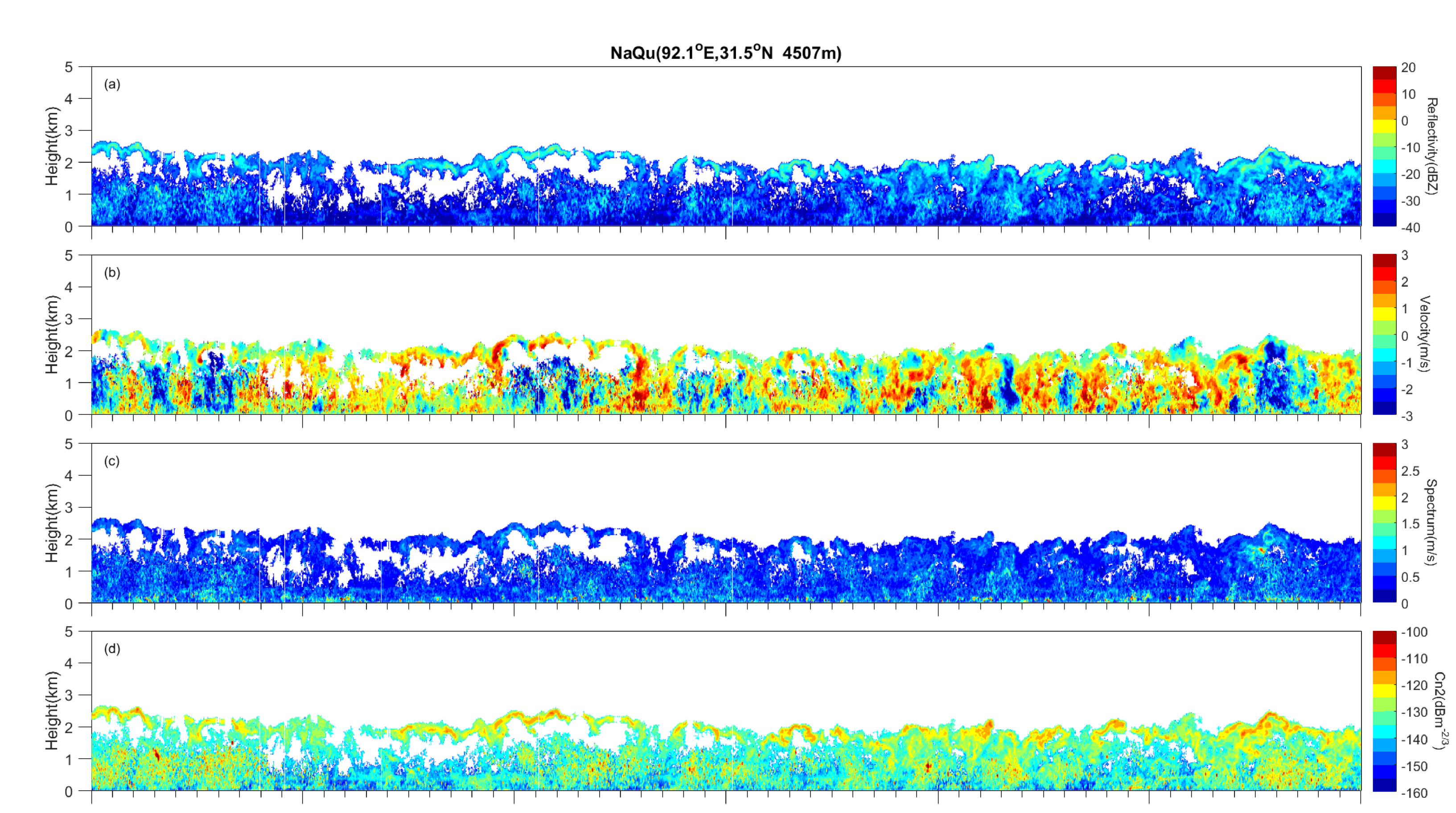

Fig.8 Time-height section of reflectivity, velocity , speed width and C_n^2 during 1500-1700 on Jul.26, 2014, Tibetan.

(a)Reflectivity (b)Vertical velocity (c) Speed width (d) C_n^2

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