

Preliminary Results of the First Observation with an Airborne Cloud Radar(SPIDER)

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Airborne Cloud Radar named SPIDER has been developed by Communications Research Laboratory and the first experiments of cloud observation was performed in this January on 1998. SPIDER was designed to use for not only airborne but also ground-based. Antenna scanning mechanism is useful to observe 3-dimensional profiles of cloud. (Figure 1)

The frequency of the radar was decided W-band (95GHz) to have enough sensitivity for cloud particles. To sense cloud which consists of small hydrometeors, a short wavelength radar has better sensitivity advantage than ordinal weather radar because the backscattering cross section of cloud particles is proportional to inverse fourth power of λ for Rayleigh scattering [1]. The short wavelength can make small aperture antenna relative to long wavelength antenna with equally gain. The disadvantage of short wavelength is huge attenuation by water or water vapor in air. The antenna diameter of SPIDER is 40 cm and gain of that is 49dBi. For system major parameters, see Table 1. For the block diagram of SPIDER, see Figure 2.

The multi-parameter function can be used to identify cloud particles. There are six measurable parameters, which are $|H|$, $|V|$, I_h , Q_h , I_v , Q_v . They are calculated to Z_h , Z_v and pulse pair data in real time. FFT mode is also prepared. ZDR, LDR and Doppler frequency are calculated by off line. To identify hydrometeors of cloud, polarimetry functions such as ZDR and/or LDR are necessary. Doppler function also helps them [2].

During January of 1998, the system was integrated into Gulf Stream II and tested. On January 26, 27 and 29 the instrument was flown over Japan Sea region. At this time, cloud was developed and it had heavy snow. Figure 3 shows image of data taken during this period. It is displayed on our web page. (http://www.crl.go.jp/ka/earth/SPIDER_98_1.html) Figure 4 is same image as Figure 3, but data are averaged. The image that was shown as a figure 4 was taken on Jan. 27, 1998 at Japan Sea. An airplane was flown from off gulf-Toyama to over land. Because absolute calibration was not performed at this time, the brightness of this image is displayed in proportional to not Z factor but received power. Antenna was located nadir looking and image shows clear vertical structure along flight pass. Echoes under sea surface line show mirror images. Figure 5 shows cloud and snow on mountains. Both images show the structure of cloud. Their original images are color. (see our web page addressed above.)

While the quality of images taken by SPIDER in this period are satisfied to measure the 3-dimensional structure of cloud. The analysis using polarization function and pulse pair data is expected.

We have done second experiments on March 1998. It is also good data. Quick image web site is http://www.crl.go.jp/ka/earth/SPIDER_98_3.html or <http://www.crl.go.jp/ka/earth/SPIDER/exp9803/index.html>.

Reference

- [1] R. A. Krofli and R. D. Kelly, "Meteorological Research Applications of MM-Wave Radar", Meteorol. and Atmos. Phys., 59, pp. 105-121, 1996.
- [2] R. J. Doviak and D. S. Zrnic, "Doppler Radar and Weather Observations", Academic Press, Inc.

Table 1 Major parameters of CRL Airborne Cloud Profiling Radar (SPIDER)

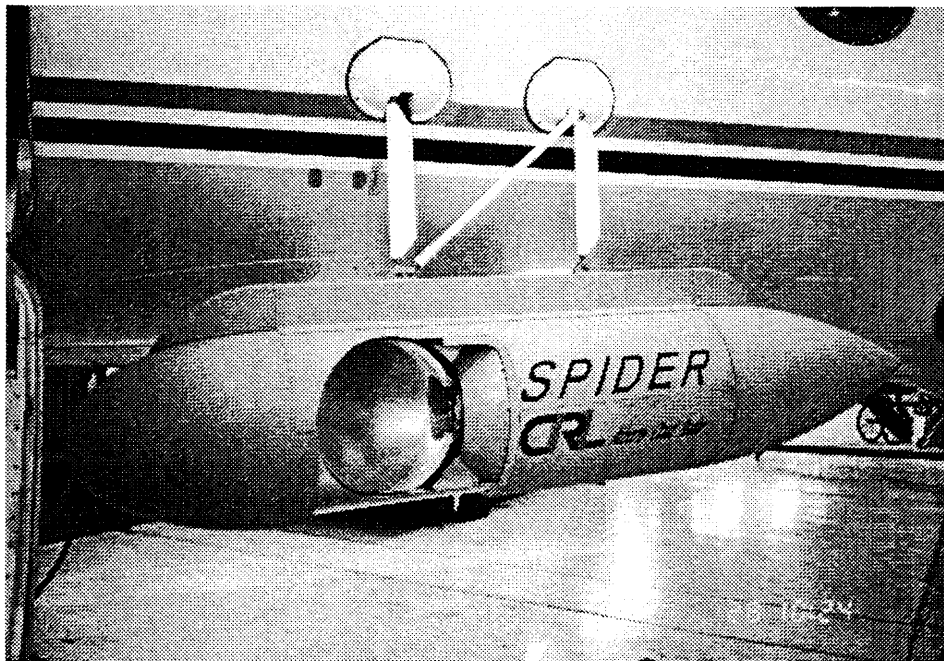
Major characteristics of CRL Airborne Cloud Radar (SPIDER)

Frequency	95.04GHz
Antenna Aperture	40cm
Antenna Beam Width	0.6degree
Antenna Gain	49.3dBi(H), 49.5dBi(V)
Transmitting Power	930W
Maximum Duty Cycle	0.01
Pulse Width (PW)	0.25, 0.5, 1.0, 2.0 μ sec
Pulse Sequence	1, 4 or 6 sequences
Pulse Spacing Time	arbitrary (more than 10x PW)
Transmitting Polarization	linear, H or V
Receiving Polarization	linear, H and V
Receiver NF	5dB (LNA)
Dynamic Range	70dB
Pulse Pair Processing	real time
FFT Processing	real time
Raw Data Recording mode	YES
Antenna Scanning	-40~95 deg.
Flight Altitude	13km
Maximum Speed	700km/h

CRL Airborne Cloud Profiling Radar



Cloud Radar is installed to Gulf Stream II



Radar Pod with Antenna opened

Figure 1 upper: Cloud Radar installed to Gulf Stream II
bottom: Radar Pod with Antenna opened

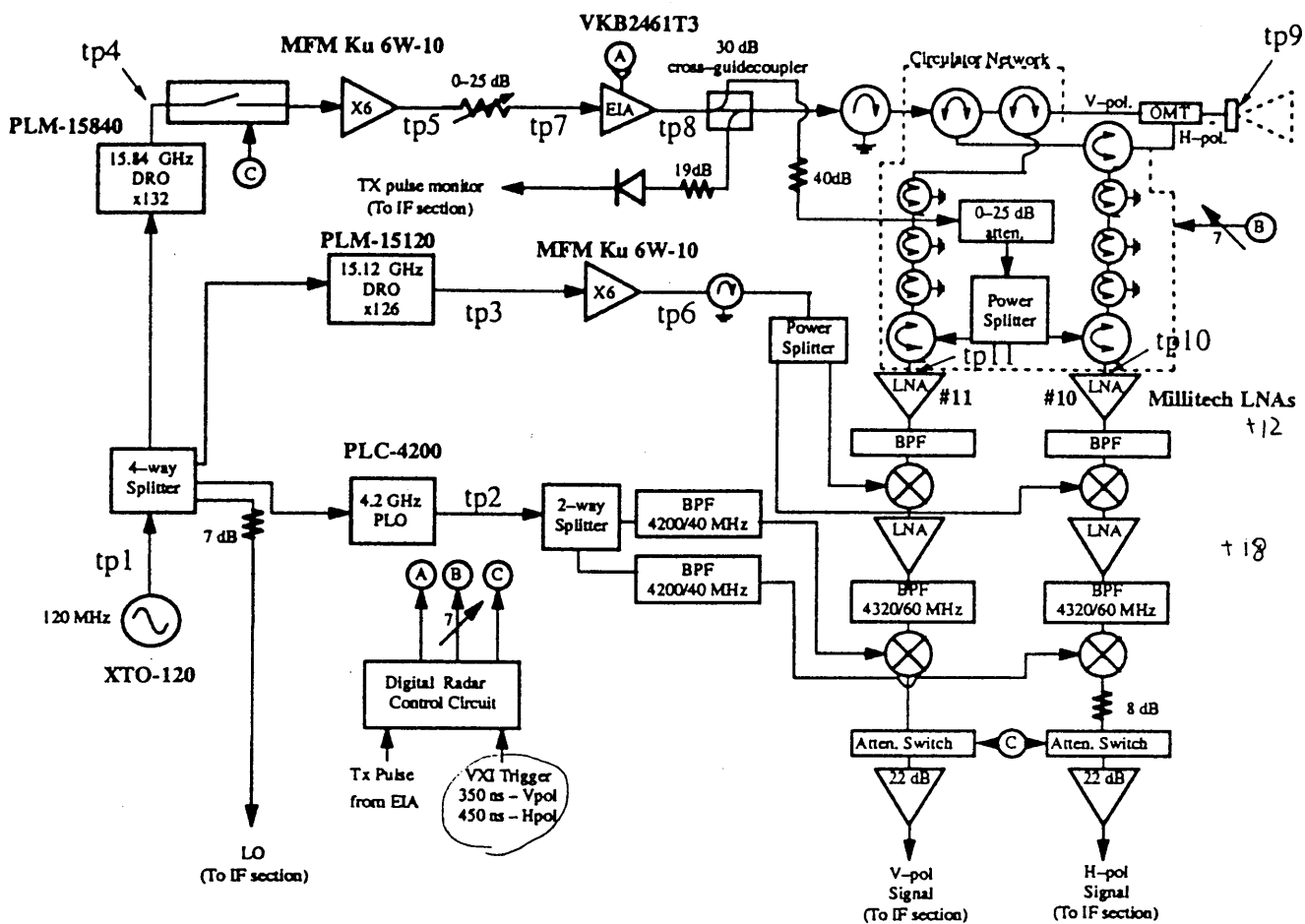


Figure 2 System Block Diagram

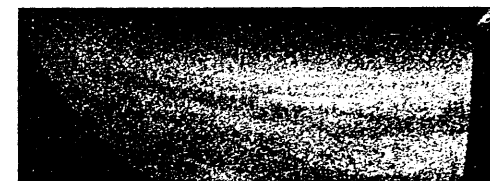
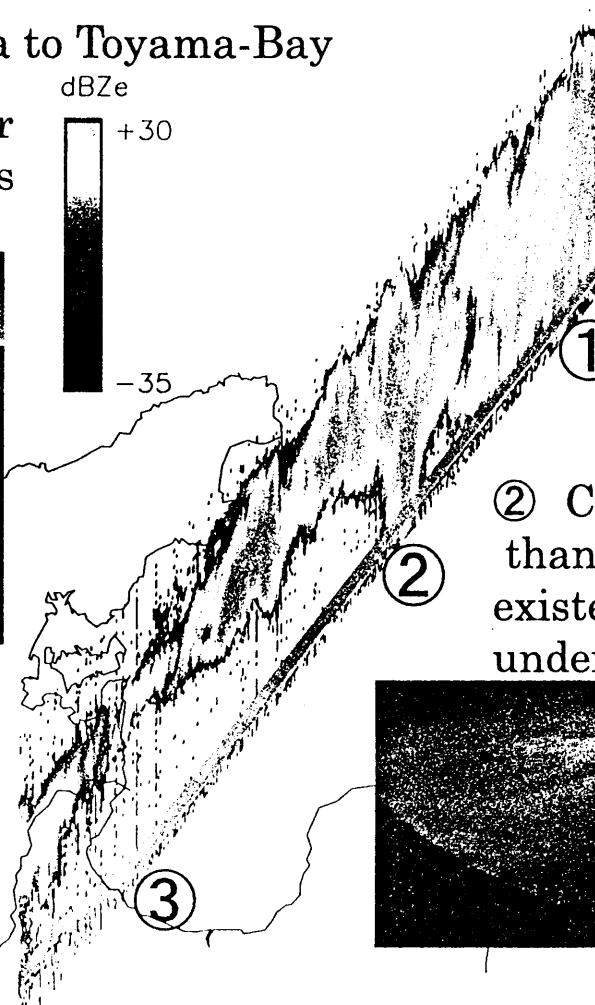
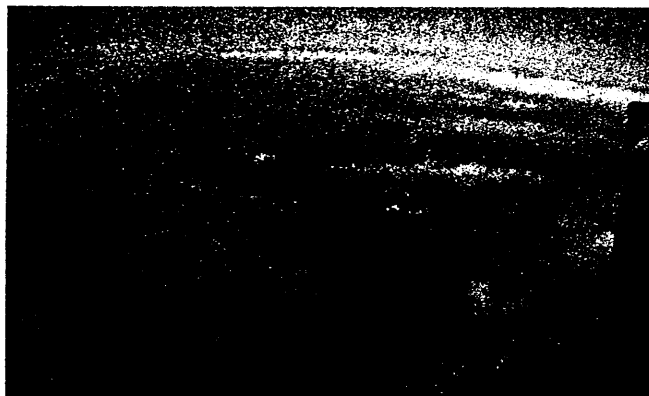
The First Result of Test Flight with CRL Airborne Cloud Radar (SPIDER)

Flight Date: Jan. 27, 1998, 12:24PM to 12+32PM

Flight Altitude: 5 km

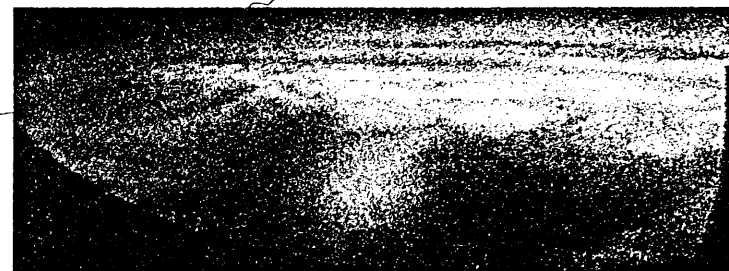
Flight Path: Off Noto-peninsula to Toyama-Bay

③ Few clouds were spread near coast line. The sight of land was visible.



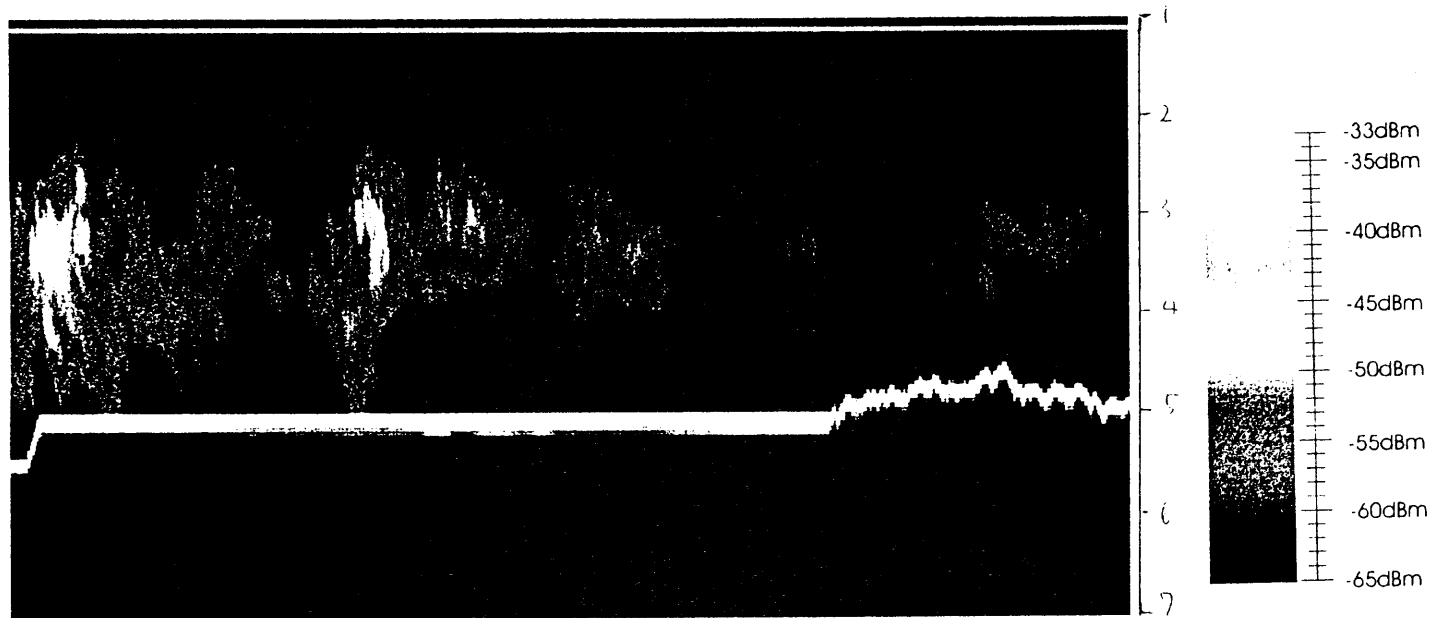
① Clouds were distributed uniformly. Cloud top was flat. Invisible under clouds.

② Cloud top height was higher than that of others. It shows existence of the hydrometeor under clouds.



Kashima Space Research Center Earth Observation Technology Section
Global Environment Division Microwave Remote Sensing Section

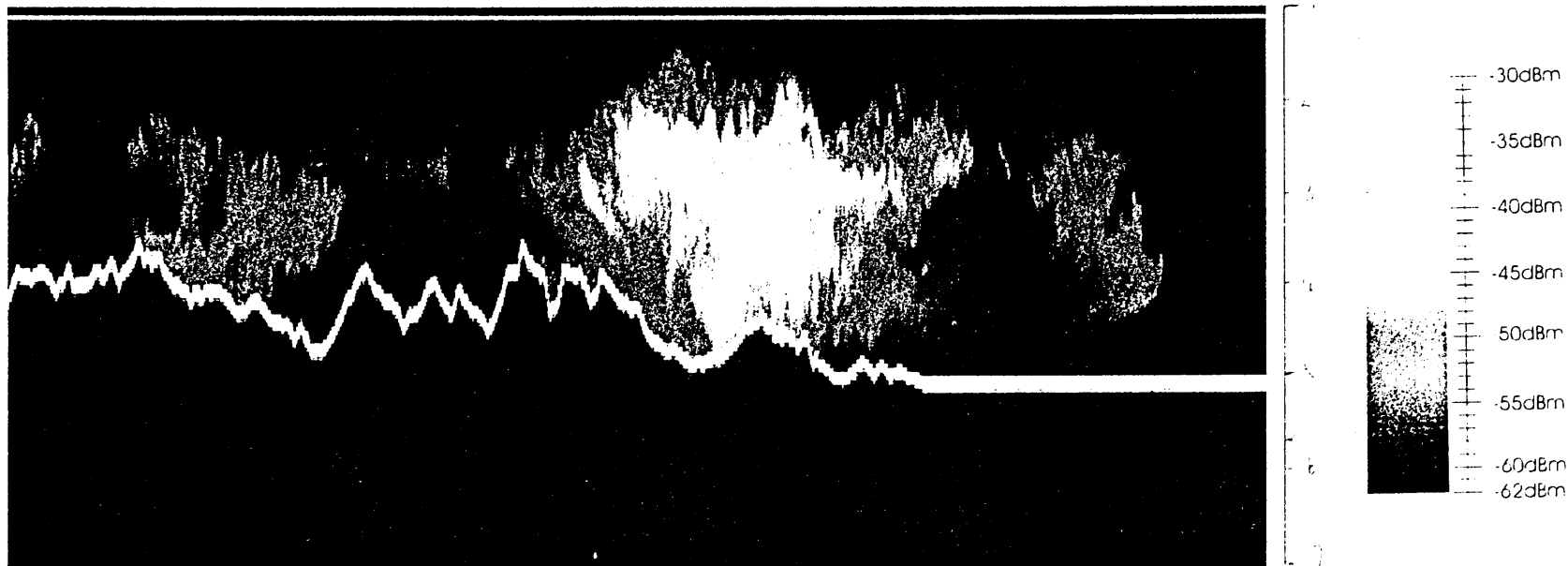
Figure 3 Web Page of SPIDERS first experiment
http://www.crl.go.jp/ka/earth/SPIDER_98_1.html



100km

98 Jan 27 W703 2/28 r 1000 9000 16 a 0.134 1 -65 100 1000 1000 1000

Figure 4 Quick Look Image taken by SPIDER during first experiment



Jan 27 98 117025527 r 700 11800 8 a 0 134 1 -62.0 0 0.0 0.0 0.0 0.0

Figure 5 Same as Figure 4, but different time.