Intercomparisons of Cloud Observations from the AL S-band Profiler and the ETL K-band Millimeter-Wave Cloud Radar on the R/V *Ronald H. Brown* during Nauru99

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Introduction

Nauru99 took place in the western and central Pacific during June and July 1999. During Nauru99, a diverse suite of instruments was located on the research vessel (R/V) *Ronald H. Brown* to measure cloud radiative interactions, among other things. An important observational tool for the Atmospheric Radiation Measurement (ARM) Program is the Millimeter Wave Cloud Radar (MMCR) developed for ARM by the Environmental Technology Laboratory (ETL) (Moran et al. 1998). The MMCR is a sophisticated instrument designed to continuously monitor the vertical structure of a variety of clouds. It is designed to operate unattended and provide cloud observations with high vertical and temporal resolution.

During the Nauru99 campaign, an Aeronomy Laboratory S-band profiler and an ETL Ka-band MMCR were collocated on board the R/V *Ronald H. Brown*. In this paper, we compare cross sections of radar reflectivity observed by the two radars during the Nauru99 cruise.

Instrumentation

The S-band profiler operates at 3 GHz and the MMCR operates at 35 GHz. Both systems were nominally vertically pointing without the stabilization commonly used for shipboard wind profilers. The S-band system operated in two modes: a 60-m high-resolution low mode and a 500-m low-resolution high mode. The MMCR was operated in four modes—two of which were pulse coded to optimize sensitivity. The coded 90-m mode of the MMCR is the most sensitive MMCR mode to cirrus. The uncoded 90-m mode is most appropriate for observations of precipitating clouds.

Intercomparisons

In order to illustrate the capabilities of the S-band and MMCR, we compare the reflectivities observed by the two instruments. We have chosen two types of events to compare: June 28 illustrates observations of high clouds and June 27 illustrates a convective rain event. The parameters used for the two radars in these intercomparisons are shown in Table 1.

Table 1. Parameters used for S-band profiler and MMCR in Nauru99.

Parameters	S-band Coded Cloud Mode	S-band Precipitation Mode	MMCR Coded Cloud Mode	MMCR Precipitation Mode
Frequency/ Wavelength	2835 MHz/ 10.6 cm	2835 MHz/ 10.6 cm	34.86 GHz/ 8.66 mm	34.86 GHz 8.66 mm
Peak Power/ Pulsewidth	500 watts/ 500 m	500 watts/ 60 m	100 watts/ 90 m	100 watts/ 90 m
Antenna/ Bandwidth	8 ft dish/ 2.9 degrees	8 ft dish/ 2.9 degrees	10 ft dish/ 0.2 degrees	10 ft dish/ 0.2 degrees
Maximum Height	17.7 km	6.3 km	20 km	20 km
Maximum Radial Velocity	5.1 m/s	13.9 m/s	3.4 m/s	15 m/s
Spectral Points	128	128	64	128
Coherent Average	32	26	4	1
No. Spectral Ave.	75	77	16	20
Dwell Time	58 s	36 s	6 s	11 s

Figure 1 shows the time-height cross section of deep clouds observed on June 28, 1999. The top panel of Figure 1 contains the time-height cross section of the coded 90-m mode for the MMCR and the bottom panel of Figure 1 contains the time-height cross section of the 500-m S-band profiler. Note that the two instruments see the same cloud structure. The major difference between the two sets of observations is the superior resolution of the MMCR. This means that with some degradation in vertical resolution and some averaging in time, the S-band system is capable of seeing the same thin clouds detected by the MMCR.

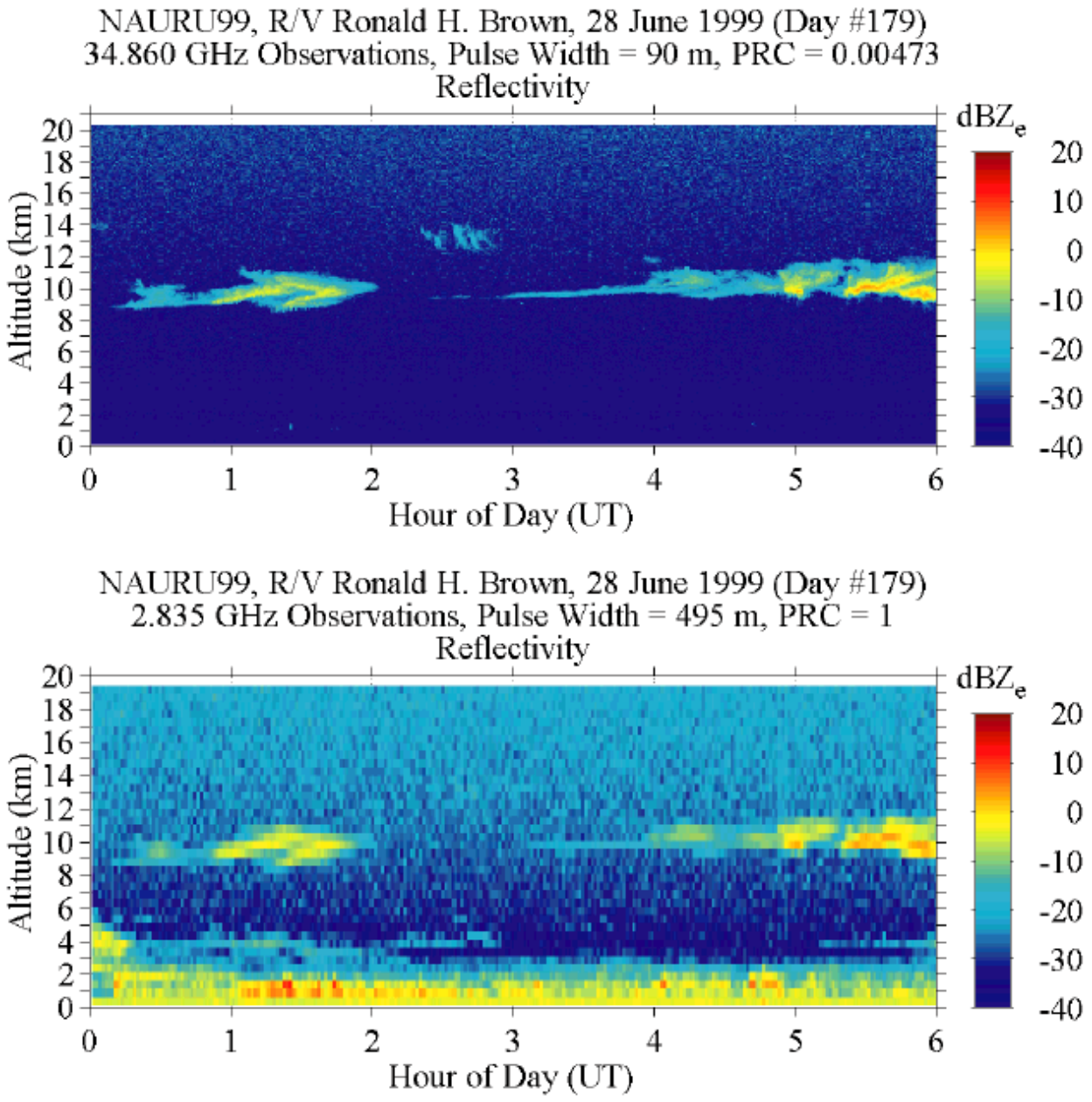

Figure 1. Time-height cross sections of reflectivity for high clouds observed on June 28, 1999, by the MMCR (top) and the S-band profiler (bottom).

Figure 2 shows the time-height cross sections for June 27 for the following modes: (a) MMCR-uncoded 90-m mode, (b) S-band 500-m mode, and (c) S-band 60-m mode. In this example, thick clouds and precipitation are present. The MMCR signal is attenuated and the S-band 500-m mode is saturated due to the rain.

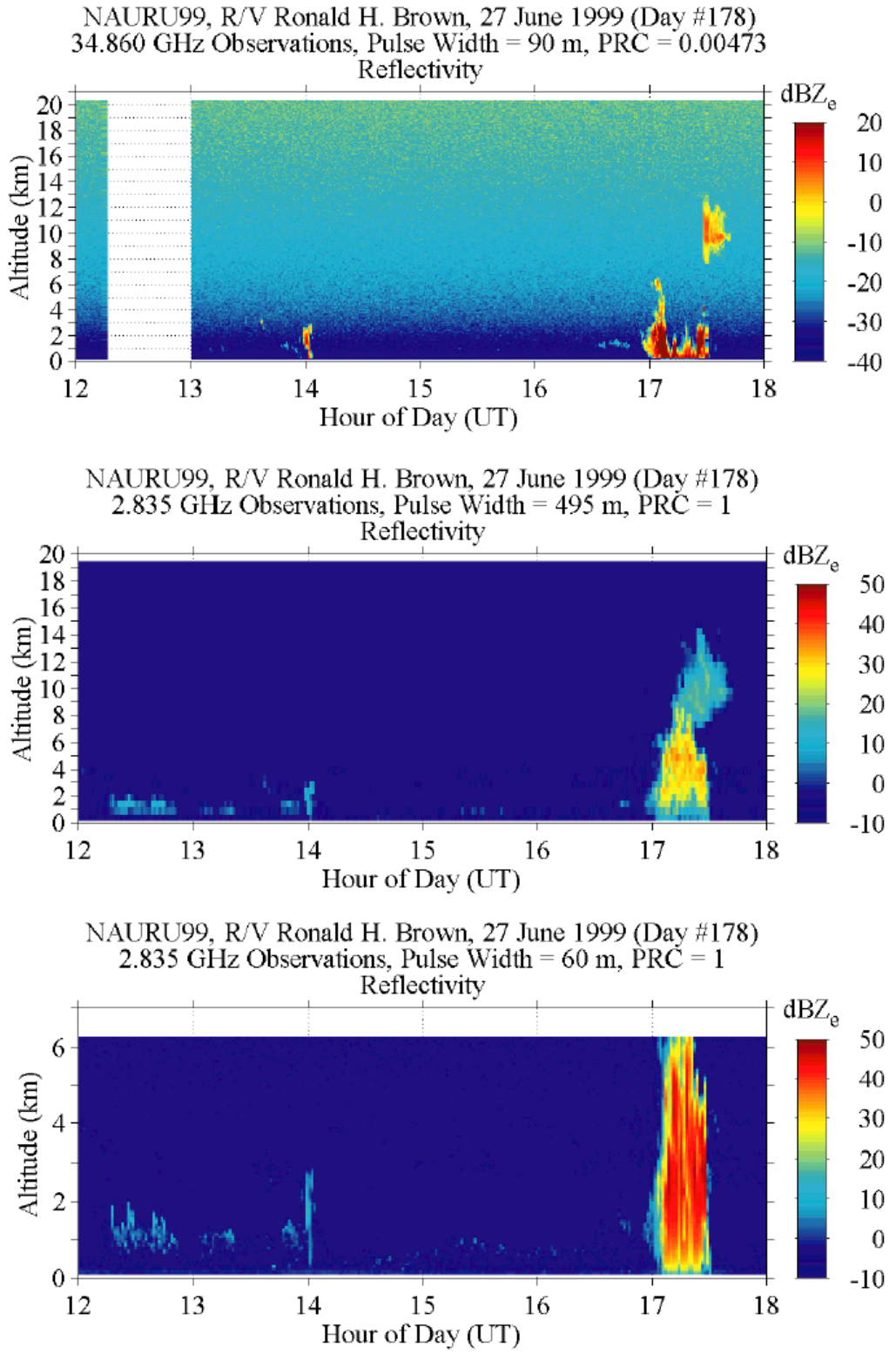

Figure 2. Time-height cross sections of reflectivity for precipitation event observed on June 27, 1999, by the MMCR (top), S-band 500-m mode (middle), and S-band 60-m mode (bottom).

Conclusions

Nauru99 took place under La Niña conditions, so the Nauru region was unusually dry. Nevertheless, enough clouds and precipitation were present to intercompare the observations from the two systems on many days. Operating in the high mode, the S-band profiler was able to detect even the high clouds seen by the MMCR albeit with coarser resolution. Overall, the S-band profiler and the MMCR worked very well on the R/V *Ronald H. Brown* without any special provisions for stabilization. At its lower frequency, the S-band system is much simpler and less affected by attenuation in rain, making it a good choice for cloud and precipitation studies especially when very high vertical resolution measurements are not required.

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