Observations of High-Level Cirrus Clouds by the NOAA Depolarization Lidar During Nauru99

J. M. Intrieri and S. Sandberg
National Oceanic and Atmospheric Administration
Environmental Technology Laboratory
Boulder, Colorado

Abstract

During the Nauru99 field campaign, the National Oceanic and Atmospheric Administration's (NOAA's) depolarization and backscatter lidar (DABUL) obtained cloud data from aboard the research vessel Ron Brown. This lidar system, which obtains information on cloud occurrence and phase, documented a variety of cloud scenarios: boundary layer water clouds; mid-level, mixed-phase cloud systems with precipitation; and high-altitude ice phase cirrus clouds. This latter cloud type is especially interesting and emphasized here because it was often not detected by other instruments.

Introduction

Clouds are critical regulators of climate and weather. Understanding their radiative impact is challenging on any scale and over any region. For example, although the Tropical Western Pacific is known to be a source of energy on a planetary scale, the specifics of this heat engine are not well understood. The Nauru99 field program was designed to obtain measurements on the radiant heat transfer and the effects of clouds on ocean weather processes in the tropics through measurements over land, in air, and under the ocean with a variety of instrumentation. The platform for the ocean-based Nauru99 ship measurements was NOAA's Ron Brown, which has been conducting an ongoing research mission around the world since 1998.

One of the many specialized instruments aboard the Ron Brown was the DABUL system. This lidar was on-loaded July 4, 1999, at Darwin, Australia, for the 1-month-long intensive campaign designed to make observations in the vicinity of Nauru Island. The lidar obtained 20 days of data between June 11 and 26 and July 12 through 15. Laser failure was the cause of the measurement gap between June 27 and July 11, which was the date of the first available crew change that afforded the laser swap. However, even with the interruption, this data set reveals many cloud scenarios including boundary layer water clouds; mid-level, mixed-phase cloud systems with precipitation; and high-altitude ice phase cirrus clouds, which were at times not visible by eye.

The Lidar System

The cloud measurements presented here were obtained using the DABUL (Figure 1). This system, developed in 1995 at NOAA's Environmental Technology Laboratory (ETL), was designed to operate unattended in any environment to obtain continuous profiles of atmospheric backscatter and depolarization ratio (Grund and Sandberg 1996).

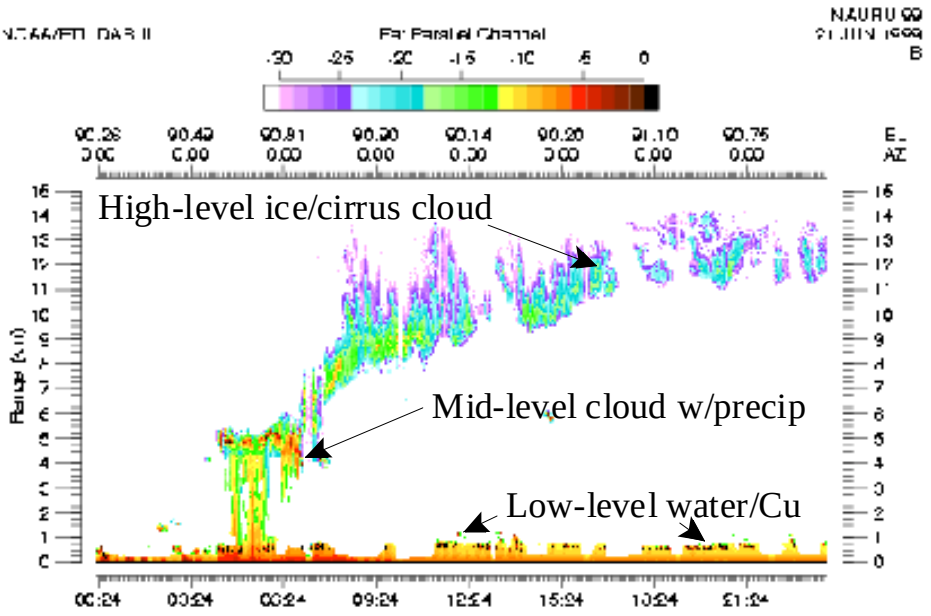

Figure 1. 24-hr time-height plot of DABUL-returned power measurements.

The DABUL optics are housed in a weatherproof container that is environmentally controlled for the temperature and humidity of the optics and electronics. This lidar, which was statically mounted for Nauru99 (Figure 2), can obtain full horizon-to-horizon measurements when coupled with a specifically designed cradle.

DABUL operates at a wavelength of 523 nm. Typically, the pulse energy of the laser is 40 μJ inside of the DABUL unit but is reduced to 25 μJ due to losses by the time it exits from the top of the container (Grund and Sandberg 1996). The combination of low laser pulse energies (micropulse) and a large beam diameter makes the DABUL system fully eye-safe (Alvarez et al. 1998). By employing high pulse rates and averaging for longer time intervals, adequate signal-to-noise ratio is easily obtained throughout the entire troposphere and into the lower stratosphere. Data were recorded each second out to 60 km with a range resolution of 30 m. Instrument specifics are presented in Table 1 and additional information can be found at http://www2.etl.noaa.gov/DABUL.html. All of the DABUL cloud data from Nauru can be viewed at http://www2.etl.noaa.gov/lidar_img/nauru_june.html.

Figure 2. DABUL on the Ron Brown.

Table 1. DABUL specifications.	
Wavelength	523 nm
Range Gates	30 m
Temporal Averaging	1 s
Transmit Beam, Div	0.3 m, 20 microrads
Receiving FOV	100, 640 microrads
Detection	Photon Count / PMT
Laser Power	40 microjoules
Repetition Rate	2000 Hz

Observations

Cloud occurrence and height information are obtained from DABUL by simply thresholding on both the depolarization and the returned power fields. Using two threshold fields affords easier determination of cloud boundaries especially for cases like very low-signal cirrus whose depolarization ratios are often very high. Additionally, precipitation can most often be included or not since the phase and power can be used to discriminate it from cloud. After the cloud layer heights are determined, a depolarization ratio for that layer is calculated to determine the phase. The processed cloud data presented here were averaged for 3 min. All of the DABUL data from Nauru have been processed for cloud boundary data (Figure 3). In general, for the times DABUL was operating, clouds were detected 46% of the time, with clouds predominantly occurring below 1500 m and above 8000 m.

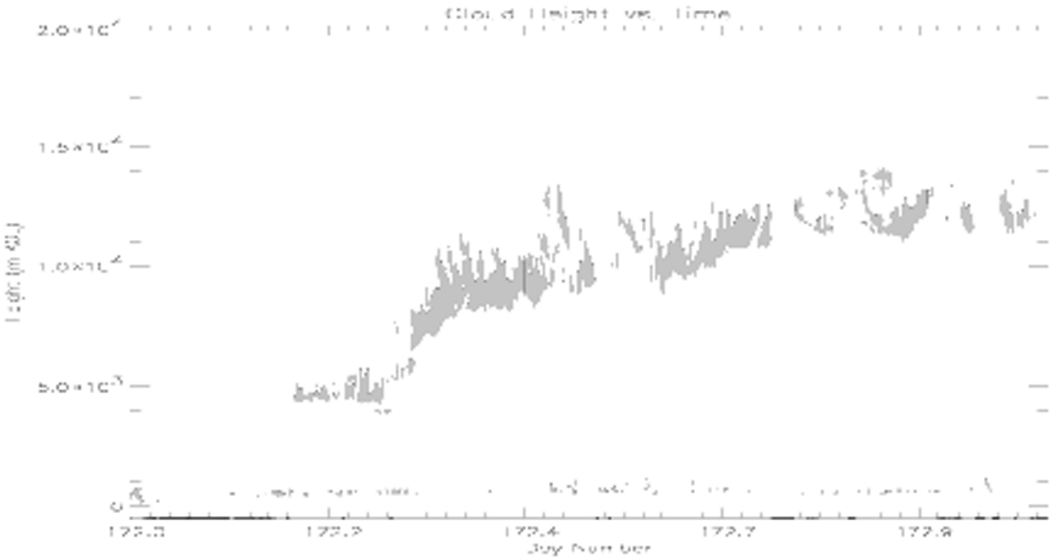

Figure 3. Cloud boundaries determined from DABUL data (shown in Figure 1).

We plan to continue to work with the Nauru data to obtain additional cloud properties. We are also combining the lidar cloud data with radar measurements to provide a complete cloud product, which will ultimately be used to interpret how the clouds affect other quantities measured during Nauru99 such as fluxes.

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Corresponding Author

J. M. Intrieri, jintrieri@etl.noaa.gov

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