A Comparison of Shipboard and Island Observations from the Combined Sensor Program

A. B. White
Cooperative Institute for Research in Environmental Sciences
University of Colorado
NOAA-Environmental Technology Laboratory
Boulder, Colorado

C. W. Fairall and M. J. Post
NOAA-Environmental Technology Laboratory
Boulder, Colorado

Introduction

Two issues concerning the Tropical Western Pacific (TWP) Atmospheric Radiation and Cloud Stations (ARCS) are these: To what degree are the measurements obtained from the island ARCS influenced by the islands themselves? What is the spatial representativeness of measurements from individual ARCS in the TWP region? The 1996 Combined Sensor Program (CSP) (Post et al. 1997) gave an opportunity to address these questions by providing coincident meteorological observations from the R/V *Discoverer* and from the ARCS on Manus Island, Papua New Guinea. In this paper, we present comparisons from the 10-day period during the CSP when the R/V *Discoverer* was stationed at various distances (<10 km, ~30 km, and ~100 km) from Manus Island (see Figure 1). We compare the overhead cloud fraction of low-level clouds measured by laser ceilometers deployed on the ship and the island. We then compare the average solar irradiance measured on the two platforms to see if there is any difference in the shortwave forcing associated with the low cloud fraction. We are unable to compare the longwave fluxes because of operational problems associated with the island's longwave radiation sensor.

We compare the wind profiles measured by 915-MHz wind profilers deployed on the ship and the island to investigate the general representativeness of the island profiles. White et al. (1997) compared the different ship-based wind sensors deployed during the CSP and demonstrated the difficulty in obtaining accurate low-level winds from shipboard wind profilers because of the contaminating signals received from sea clutter. They indicated that during the CSP most of the contamination was confined to the lowest 220 m.

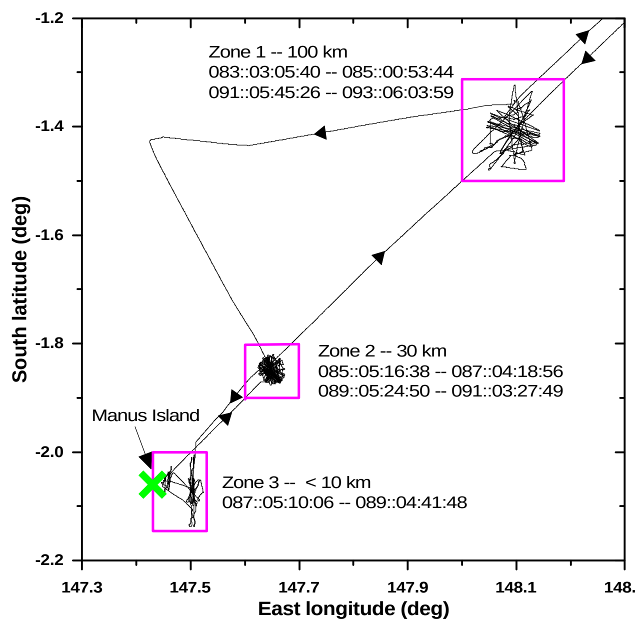

Figure 1. Map showing a portion of the R/V *Discoverer* cruise track taken during the 1996 CSP. Julian dates and times (UTC) are listed for periods when the ship was in each of the zones identified by the boxes. (For a color version of this figure, please see *http://www.arm.gov/docs/documents/technical/conf_9803/white-98.pdf*.)

Cloud and Shortwave Radiation Comparisons

In addition to measurements of cloud base, laser ceilometers provide information on the overhead cloud fraction by providing a time series of the "cloud" or "no-cloud" status (White et al. 1995). This cloud fraction differs from that provided by a human observer or derived from satellite data. First, the maximum instrument range for the shipboard ceilometer (Vaisala model CT 12K) is 3.8 km. Therefore, mid- and high-level clouds are not detected by this device. The island ceilometer (Vaisala model CT 25K) has a range of 7.6 km resulting from an increase in pulse repetition frequency and, consequently, a larger, average power. Despite the difference in power, White (1997) found that these two ceilometers have nearly equivalent detection sensitivities to low-level clouds. Second, the ceilometers point vertically and do not scan, so the deduced cloud fractions are based solely on the clouds that pass directly over the instrument during a specified averaging period, which we chose to be one hour.

Figure 2 shows the diurnal average of the hourly overhead cloud fractions measured on the ship and the island for the entire 10-day comparison period. The island ceilometer measured a higher average low-cloud fraction (0.29) than did the shipboard ceilometer (0.18). We compared the solar irradiance data recorded by pyranometers on the ship and the island. These two instruments were cross-calibrated after the CSP using data from a third pyranometer that was passed between the ship and the island during the cruise. The average difference in solar irradiance (ship–island) was 3.3 Wm^2 over the 10-day period. The sign of this difference is consistent with the observed low-cloud fractions, but the magnitude may not be significant given the current level of uncertainty in the surface energy budget in the TWP region. It is also possible that the observed solar irradiances were

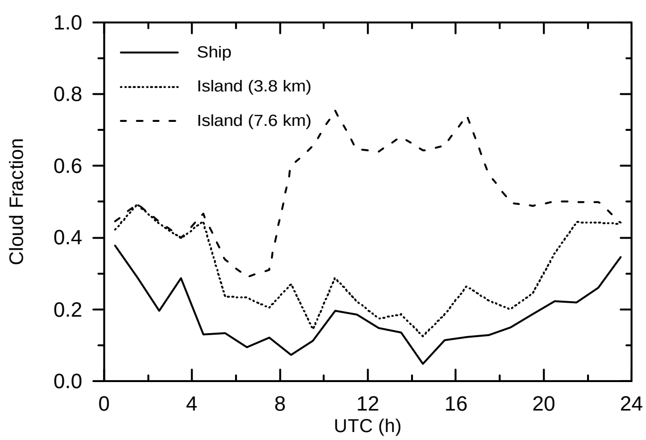

Figure 2. Diurnally averaged cloud fraction measured by the laser ceilometers deployed on the R/V *Discoverer* and on Manus Island. The solid and dotted curves are for clouds with base elevations less than 3.8 km. The dashed curve is for clouds with base elevations less than 7.6 km.

influenced more heavily by the clouds with base elevations above 3.8 km. For example, the cloud fraction measured on the island between 0900 Greenwich Mean Time (GMT) and 1900 GMT is dominated by mid-level clouds (3.8 km to 7.6 km), as shown in Figure 2. We believe many of these clouds are remnants of convection occurring over the main island of Papua New Guinea.

Wind Profile Comparisons

We produced hourly wind profiles using the Environmental Technology Laboratory wind editor (Weber et al. 1993) from the raw Doppler moments data collected by the National Ocean and Atmospheric Administration (NOAA) 915-MHz wind profilers deployed on the ship and the island. Before applying the editor, we removed the mean motion of the ship from the shipboard wind profiles. During the cruise, a gyrostabilized platform was used to keep the shipboard antenna level. Diurnal time-height cross sections of the horizontal velocity components u and v measured on the ship and island are shown in Figure 3. There is a distinct diurnal pattern in both datasets, although somewhat weaker in the shipboard data. These patterns are consistent with a land-sea breeze circulation. However, the diurnal average for the shipboard data includes data collected 100 km from the island, suggesting forcing from a larger scale than Manus Island. Therefore, it is likely that the winds observed on both the ship and the island were influenced by the main island of Papua New Guinea.

We studied the spatial representativeness of the island cloud and wind observations by correlating the hourly time series from the ship and the island for periods when the ship was stationed in each of the zones shown in Figure 1. The results of this analysis are summarized in Figure 4. As expected, the wind speed and cloud statistics are highly correlated in Zone 3. As the ship moves further away from the island, the correlation for all three variables decreases. The wind speed remains more highly correlated than cloud fraction and cloud base.

Summary

We compared measurements of clouds and winds taken onboard the R/V *Discoverer* during the 1996 CSP to similar measurements taken at the ARCS site on Manus Island. We found a substantially higher low-cloud fraction above the island (0.29) than above the open ocean (0.18). The corresponding effect on the shortwave radiation was consistent with the difference in cloud fraction, but the magnitude was small (3.3 Wm^{-2}). The hourly wind profiles measured by the 915-MHz wind profilers deployed on the

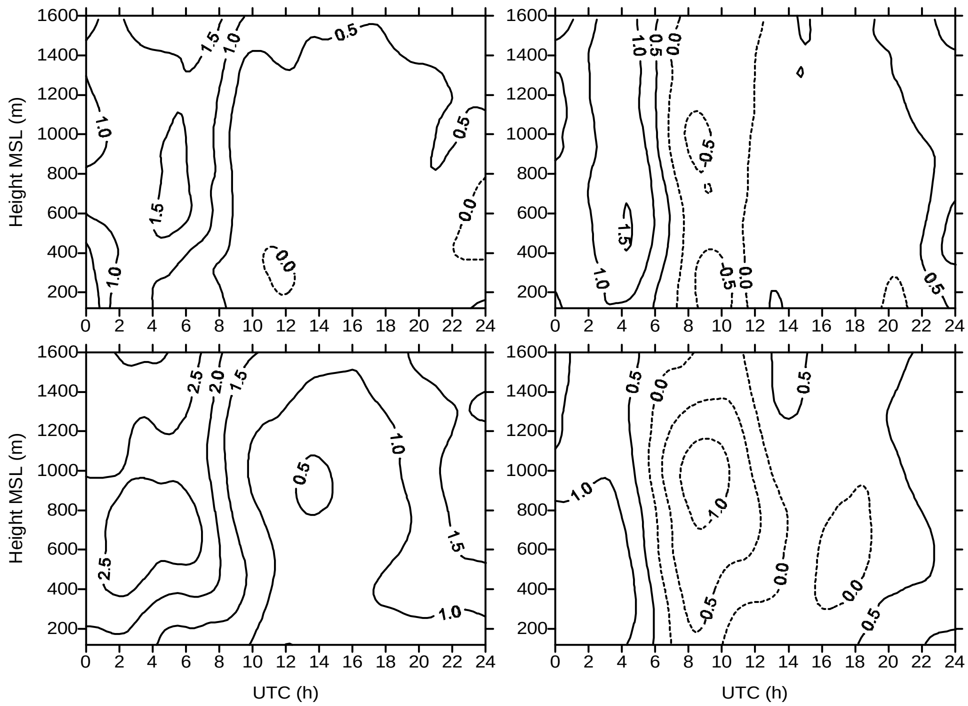

Figure 3. Diurnally averaged horizontal velocity components *u* (left panels) and *v* (right panels) measured with the 915-MHz wind profilers deployed on the R/V *Discoverer* (top panels) and on Manus Island (bottom panels). The contour labels are in m s^{-1}, and dashed contours enclose negative velocities.

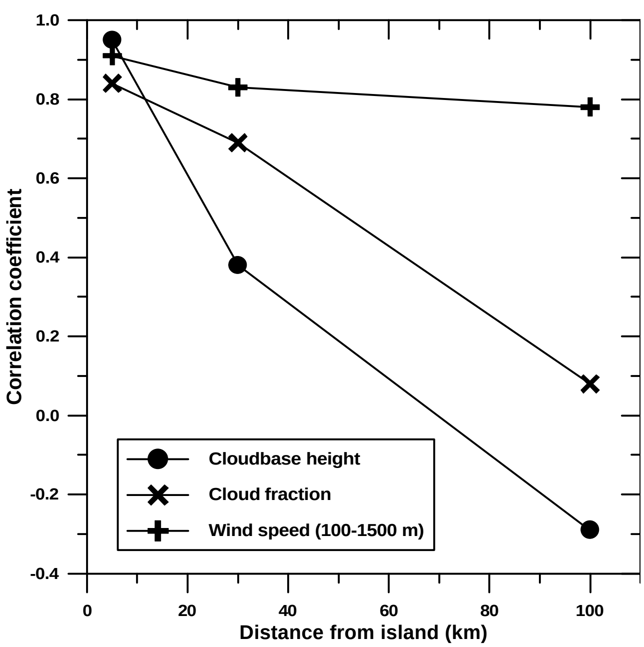

Figure 4. Correlation as a function of distance from Manus Island for the cloud and wind measurements recorded on the R/V *Discoverer* and on Manus Island.

ship and the island were well correlated even out to a separation distance of 100 km. The similarity in the diurnal behavior of the horizontal velocity components suggests forcing from a land mass larger than Manus Island, presumably the main island of Papua New Guinea. Further study is needed to quantify island effects and the spatial representativeness of the individual TWP ARCS. A similar experiment to the CSP is planned for 1999, when the R/V *Ron Brown* is slated to cruise in the vicinity of the new ARCS on Nauru Island.

Acknowledgments

The authors thank Chuck Long of NOAA/Air Resources Laboratory (ARL) for providing the Manus Island ceilometer and pyranometer data and Paul Johnston of NOAA/Aeronomy Laboratory (AL) for providing the Manus Island wind profiler data. Funding for this research was provided by the U.S. Department of Energy's (DOE's) Atmospheric Radiation Measurement (ARM) Program. The Combined Sensor Program was sponsored jointly by DOE and NOAA.

References

Post, M. J., C. W. Fairall, A. B. White, Y. Han, W. L. Ecklund, K. M. Weickmann, D. I. Cooper, P. Minnett, P. K. Quinn, S. M. Sekelsky, R. E. McIntosh, R. O. Knuteson, 1997: The Combined Sensor Program: An air-sea science mission in the central and western Pacific Ocean. *Bull. Amer. Meteor. Soc.*, **18**, 2797-2815.

Weber, B. L., D. B. Wuertz, D. C. Welsh, and R. McPeek, 1993: Quality controls for profiler measurements of winds and RASS temperatures. *J. Atmos. Ocean. Tech.*, **10**, 452-464.

White, A. B., 1997: A field comparison of the Vaisala CT12K and CT25K ceilometers. NOAA Tech. Memo. ERL ETL-281, NOAA Environmental Technology Laboratory, Boulder, Colorado, 9 pp.

White, A. B., C. W. Fairall, and J. B. Snider, 1995: Surface-based remote sensing of marine boundary layer cloud properties. *J. Atmos. Sci*., **52**, 2827-2838.

White, A., J. Hare, C. Williams, W. Ecklund, L. Hartten, C. Long, C. Fairall, M. Post, P. Johnston, and K. Gage, 1997: A comparison of winds and clouds observed from a ship and an island. Preprint Vol., Twenty-eighth Conference on Radar Meteorology, Austin, Texas, September 7-12, 1997, AMS, Boston, Massachusetts, 518-519.