Tropical Western Pacific Program: Status Report

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Introduction

The Tropical Western Pacific (TWP) locale is the second Cloud and Radiation Testbed (CART) locale to be implemented by the Atmospheric Radiation Measurement (ARM) Program. It is a large expanse of tropical ocean and maritime continent lying roughly between 10°S and 10°N latitude and from 135°E to 150°W longitude (Figure 1). The maritime continent area is largely in the southwest and the open ocean area in the northeast of the locale. Climatologically, the locale is characterized by warm sea surface temperatures, deep and frequent atmospheric convection, high rain rates, strong coupling between the atmosphere and ocean, and substantial variability associated with El Niño - Southern Oscillation (ENSO) phenomenon. The relationship between climatic variability in this region and variability in other areas of the planet is well known.

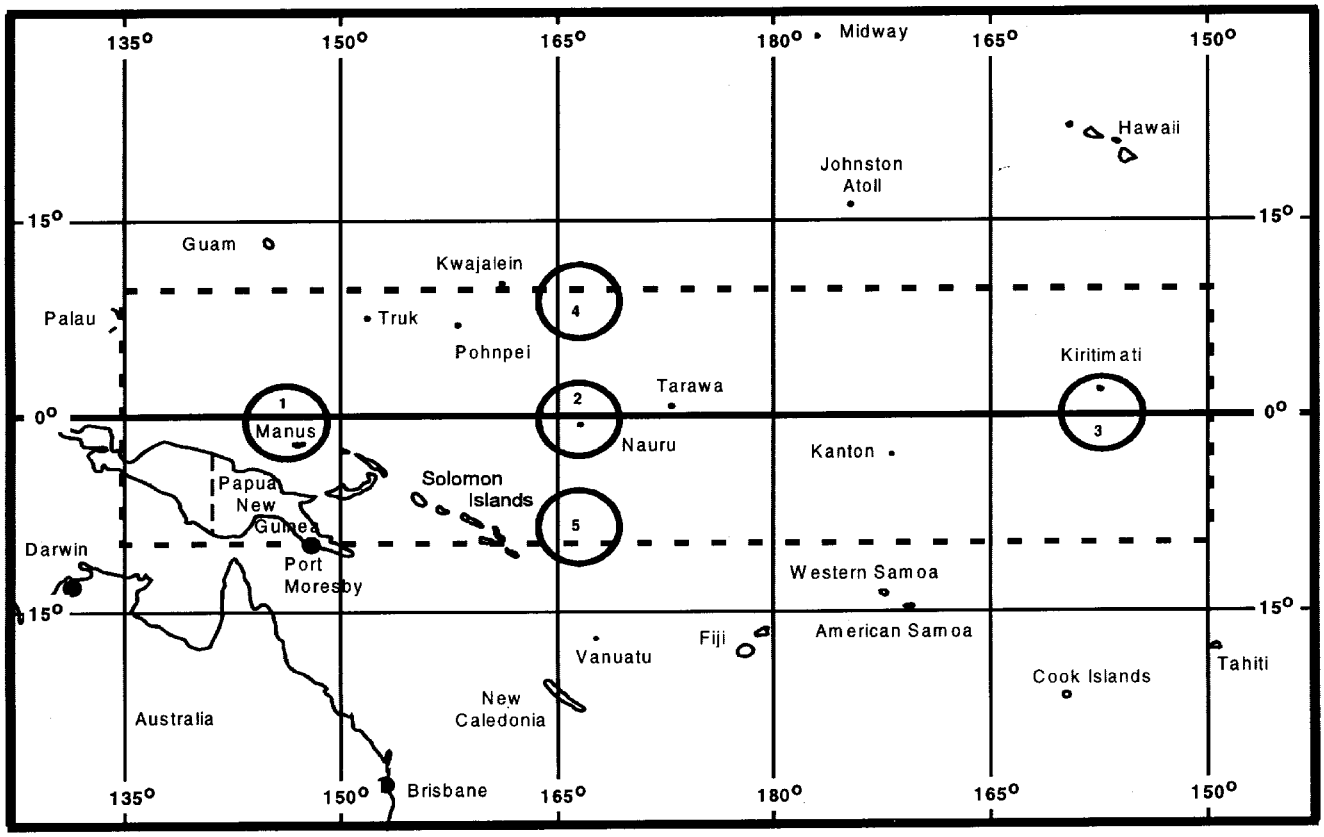

Figure 1. Equatorial Western Pacific region showing TWP locale (dashed area) and proposed Atmospheric and Radiation Cloud Station (ARCS) sites (circles).

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Scientific questions that need to be addressed in the TWP can be grouped into the three categories of radiation budget and cloud forcing, water and energy budgets, and ocean-atmosphere interactions. The many important and interesting scientific questions, the large expanse of the TWP locale, and logistical and financial constraints all come into play in designing a useful observational strategy. The current strategy has three distinct and critical elements: 1) provide a long time series of basic observations at several locations that will aid in understanding intra-annual and interannual variability of surface radiation fluxes and cloud properties; 2) augment radiation and cloud observations with intensive field campaigns to study the role of deep convection in the tropics as it affects radiative processes; and 3) devise and implement a strategy for long-term measurements of ocean-atmosphere properties and fluxes.

The first element represents the highest priority for the TWP because it relates directly to the primary scientific questions articulated by the ARM Program and because there currently are no long-term radiation measurement sites in the TWP locale with the exception of Australian facilities in the Darwin area. Hence, the first phase of implementation for the TWP locale is concentrating on this element.

ARCS

Atmospheric Radiation and Cloud Stations (ARCS) were designed to provide the long-term basic observations required in the TWP. An ARCS consists of an integrated instrument set that can measure the surface radiation balance, surface meteorology, cloud properties, and some limited atmospheric quantities. In addition to the suite of scientific instruments, an ARCS contains data acquisition systems, monitoring and control systems, satellite communications, a backup electrical generator, and other support equipment. The ARCS is housed in five specially modified 20-foot seacontainers. The ARCS system is self-contained and designed to operate semi-autonomously with a minimum of on site support.

The need to measure the effect of tropical clouds and water vapor on the surface radiation budget is the main scientific driver for the set of observations made by an ARCS. General measurement categories and the instruments used to obtain them are given in Table 1.

Table 1. ARCS measurements and instruments.

Measurement	Instruments
Surface radiation balance	Up- and down-looking pyranometers and pyrgeometers Sun-shaded pyranometer and pyregeometer Normal incidence pyrheliometer Up- and down-looking 9-11µm narrow field of view radiometers UV-B hemispheric radiometer Broad band (solar and infrared) net radiometer
Surface meteorology	Temperature and relative humidity sensor Barometer Optical rain gauge Propeller vane anemometer
Cloud properties	Cloud lidar Ceilometer (7.5 km maximum range) 35 GHz radar[(a)] Whole sky imager[(a)]
Aerosol optic depth	Multi-filter rotating shadow band radiometer (total, direct, and diffuse irradiance in six 10 nm channels)
Column water	Dual channel (23.8 and 31.4 GHz) microwave radiometer
Vertical structure of the atmosphere	Rawinsonde; 915 MHZ wind profiler with radio acoustic sounding system[(b)]

(a) Not currently installed.
(b) Operated in cooperation with the National Oceanic and Atmospheric Administration's (NOAA) Aeronomy Lab.

Siting Strategy

An important property of the climate in the tropical pacific is a strong east to west gradient in various climate parameters, including sea surface temperature, water vapor column, and frequency of convection. The TWP is characterized by high sea surface temperatures and frequent, deep convection. Toward the eastern Pacific, there is a steady decline in sea surface temperature and a corresponding decrease in the frequency of convection. An El Niño is a deviation from these typical east to west gradients. Because of this longitudinal structure and its variability, it would be difficult to characterize the climate of the tropical Pacific with a single site. The plan for ARM in the TWP is to deploy an ARCS at five sites to sample the structure in this region.

The existing and proposed locations of the five TWP sites are shown in Figure 1. The deployment schedule and status of the sites are given in Table 2. The current implementation plan calls for the TWP locale to be fully operational by 2002. ARM and the South Pacific Regional Environmental Programme (SPREP) are working closely together in the siting, public awareness, educational, and other aspects of implementing the TWP locale.

The Manus Site

The first site chosen to be implemented in the TWP is in Manus Province, Papua New Guinea (PNG) (Figure 2). It was chosen to be the first site in the locale because of its location within the heart of the Pacific warm pool, the existence of a NOAA Integrated Sounding System (ISS), and the support of the PNG National Weather Service (NWS). The site is located at the NWS station at the Momote airport on Los Negros Island at 2.060°S, 147.425°E (Figure 3).

The Momote site is 6 m above sea level. The highest point on Manus Island is 646 m, but most of the island has an elevation of less than 200 m. The highest point on Los Negros Island is 121 m, but within 3 km of the site, the elevation is less than 20 m. All equipment is located within the NWS compound at Momote (Figure 2). The siting, installation, and operation of the Momote site is a collaborative effort between ARM/TWP and the PNG NWS.

ARCS-1 was installed at Momote during a 6-week period that began on 24 August 1996. The site was formally commissioned on 12 September and routine operations began on 8 October.

TWP Operations

With the installation of ARCS-1 on Manus, TWP operations formally began. NWS staff are in charge of the daily operations of the Manus site. Assistance in performing these duties and in troubleshooting problems is provided by the TWP Operations Center at Los Alamos National Laboratory in the United States. Communications between the site and the operations center are conducted by phone, fax, and satellite. A REgional SErvice Team (RESET) makes periodic visits to the site to perform maintenance and calibration. These routine visits are nominally scheduled at 6-month intervals. Additional visits are made when required.

Currently, all ARCS instruments are functioning and providing data to the ARM Experiment Center. The whole sky imager and the cloud radar are not currently installed at Momote. These will be added within the next year. A new Global-Positioning-Satellite-based rawinsonde system is scheduled to be installed in August 1997.

Table 2. Proposed schedule and status of ARCS sites in the TWP.

Site	Latitude	Longitude	Start Date	Status
1. Manus	2.060°S	147.425°E	1996	Operations began in October 1996
2. Nauru	0.53°S	166.92°E	1998	Operations to start in spring of 1998
3. Kiritimati	1.87°N	157.33°W	1999	Proposed
4. Off Equator	--	--	2000	No site selected
5. Off Equator	--	--	2001	No site selected

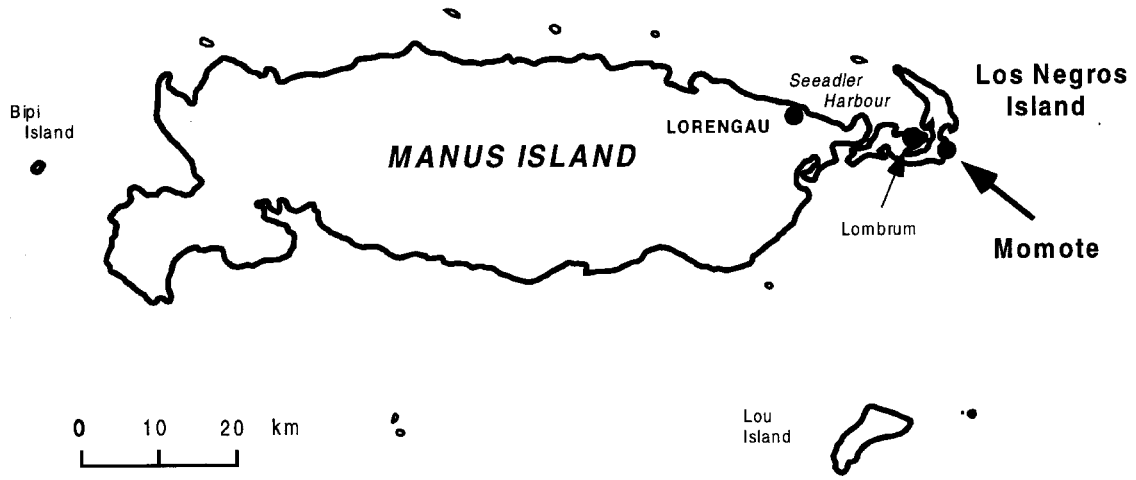

Figure 2. Manus Province, Papua New Guinea. The ARCS is located at the National Weather Service station at the Momote airport on Los Negros Island.

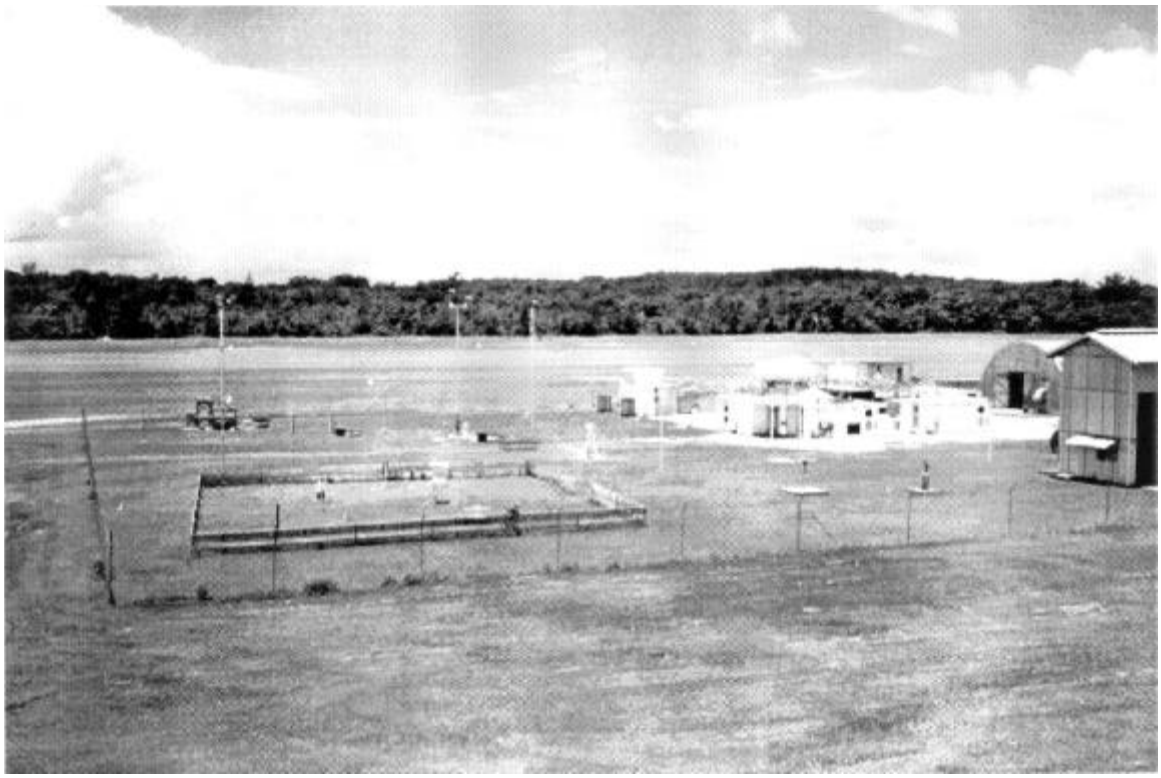

Figure 3. ARCS installation at a National Weather Service station at Momote airport, Manus Province, PNG.

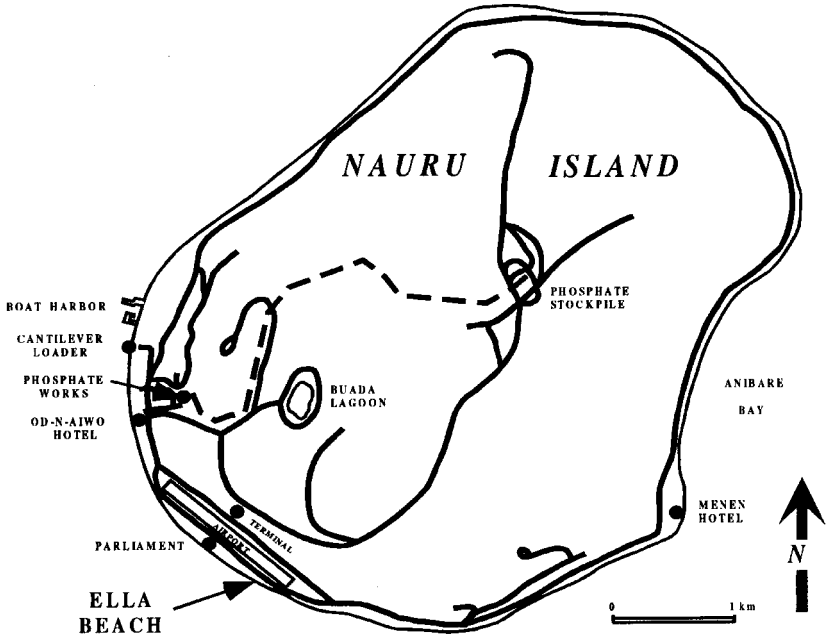

Figure 4. Nauru Island. ARCS-2 will be located at Ella Beach on the southwest shore.

The Nauru Site

The second site to be implemented in the TWP will be on Nauru Island at 0.53°S, 166.92°E (Figure 2). This site was chosen because of its location on the eastern edge of the warm pool under La Niña conditions. The Republic of Nauru has agreed to host the site, and its operations will be a collaborative effort between ARM/TWP and the Nauru Department of Island Development and Industry. The ARCS will be installed at a site on Ella Beach near the airport on the southwest end of the island (Figure 4). A new section of the seawall at Ella Beach will be constructed to enlarge the site for the ARCS. Installation of ARCS-2 is scheduled for the spring of 1998.

The Third Site

It is desired to locate the third ARCS site in a region which is normally well out of the warm pool under La Niña conditions. A possible candidate for the third site is Kiritimati Island (1.87°N, 157.33°W; Figure 2). Discussions have begun with the Kiribati government concerning this possibility. We would like to begin operations of the third site in 1999.

Subsequent Sites

The TWP siting strategy calls for the fourth and fifth sites to be at located north and south of the equator in the general areas indicated in Figure 2. No specific locations for these sites have been proposed at this time. These sites would be implemented in 2000 and 2001.

Instrumented Buoys

ARM is funding NOAA's Pacific Marine Environmental Laboratory to install short-wave radiometers on seven of the existing Thermal Array in the Ocean (TAO) buoys on the 165°E line. The radiometers will be installed on the buoys at 8S, 5S, 2S, 0, 2N, 5N, and 8N during 1997. The data will provide incoming solar radiation data over the open ocean for use with the data collected from the TWP site on Nauru.

Ship Studies and Campaigns

In order to collect data over the open ocean, ARM has to date participated in two ship studies in the TWP. ARM participated in the Combined Sensor Program (CSP) cruise in

March and April 1996 and the Japan-U.S. Tropical Ocean Study (JUSTOS) Cruise during January-March 1997. These cruises made investigations along and around the equator in the TWP locale. Both made measurements in the vicinity of Manus Island, PNG, for comparison with data collected at the ARCS site there. ARM will take advantage of other such cruises in the future and will plan campaigns in the locale to address specific scientific issues important to the program. We are also looking at the possibilities of fielding instruments on ships of opportunity that sail in the TWP.

Educational Outreach Program

Goals for the TWP Education Outreach Program were developed from discussions with host countries. The goals are 1) to enrich primary, secondary, and college programs in the TWP region; 2) to promote the development of a regional curriculum and assist with specific applications as appropriate; and 3) to focus on basic science, meteorology, climate, climate change, and climate change affects relevant to the region.

Progress with the education program includes successful collaborations with the Schools of the Pacific Rainfall Climate Experiment (SPaRCE; run by the University of Oklahoma), SPREP, Scripps Institute of Oceanography, and the South Pacific Sea Level and Climate Monitoring Project (National Tidal Facility, Flinders University, Australia). We conduct in-service training for local teachers at ARCS sites, provide equipment and materials for curriculum enrichment, and sponsor teachers to attend regional education conferences. TWP scientists and technicians visit local schools to talk with students and teachers, assist teachers in setting up and operating climate monitoring equipment, and lead field trips to ARCS facilities.

Acknowledgments

The ARM Program is sponsored by the U.S. Department of Energy's Office of Biological and Environmental Research. The program draws on the resources of most of the U.S. national laboratories, several universities, and other national and international agencies and contractors. The operation of the Manus site is a collaborative effort with the Papua New Guinea National Weather Service and that of the Nauru site and with the Nauruan Department of Island Development and Industry. Operation of the rawinsonde and wind profiler at Manus is a cooperative effort with NOAA's Aeronomy Lab. The TWP Program Office works collaboratively with the South Pacific Regional Environment Programme in all aspects of the implementation of the TWP locale. This project would not be possible without the cooperation and combined efforts of all these contributors.