Darwin ARCS3

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Introduction

Darwin is located near 12°S, 131°E and the northern coast of Australia and is affected by a classic monsoonal environment within the "maritime continent." As shown in Figure 1, almost all rainfall occurs during the period November to April associated with the onset of the annual "wet season." The rainfall

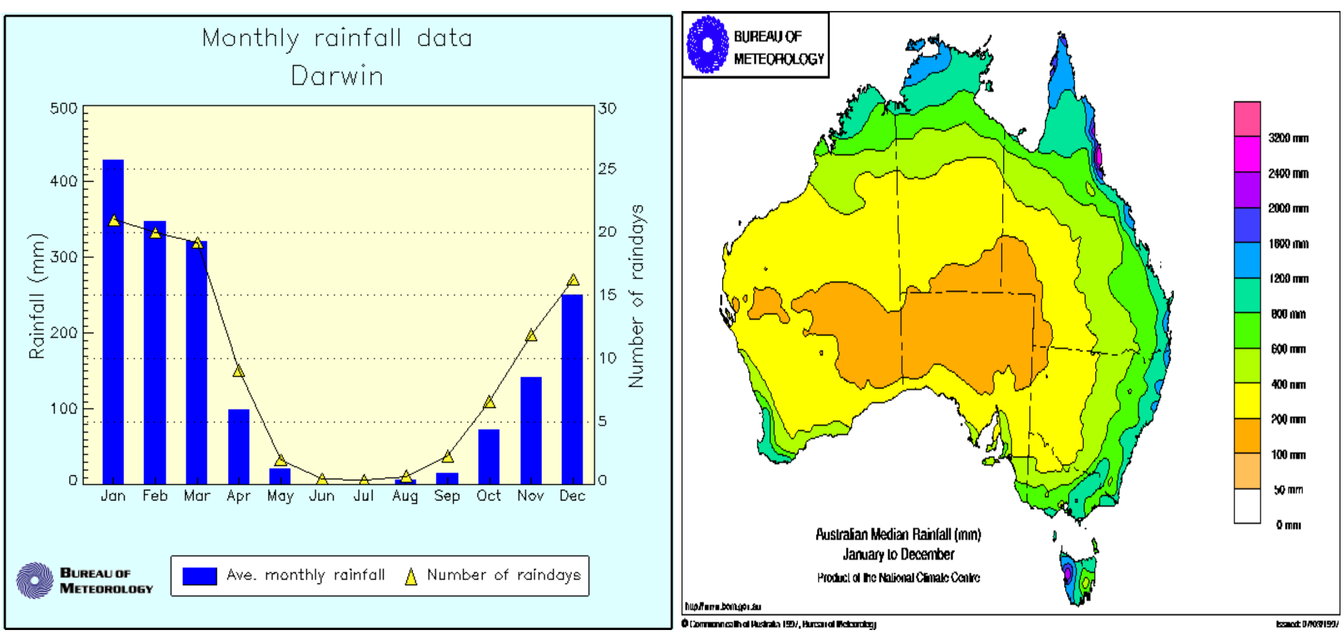

Figure 1. Annual distribution of rainfall at Darwin, Australia, (right) and associated spatial distribution (left).

is concentrated along the northern coast of Australia with a significant north-south gradient. However, northern territory rainfall is significant in the context of total rainfall production within the maritime continent. During monsoonal bursts with deep westerly flow, clouds that are oceanic in character are organized in the form of monsoonal bands, monsoonal depressions, tropical cyclones, and other meso-scale squall-like systems. During the transition and break periods of the "wet," deep easterly environmental flow of subtropical origin prevails and continental type clouds form in isolated continental thunderstorms, squall lines, and coastal convection (Keenan and Carbone 1992).

Figure 2 shows the mean annual characteristics of the radiation observed at the Darwin site, which are typical of the tropical coastal sites in Northern Australia. There is evidence of high cloud amount during the wet season and significant clear-sky periods in June, July, August, and early September. The end of the wet season is characterized by clear skies with moderate aerosol optical depths at 500 nm (0.05). By the latter part of the dry season, aerosol products from biomass burning originating from the surrounding environs or transported from the Indonesian archipelago influence the column transmittance. The highest and most variable tropospheric aerosol optical depths (AOD) (1.0) measured on the Australian mainland occur under these conditions.

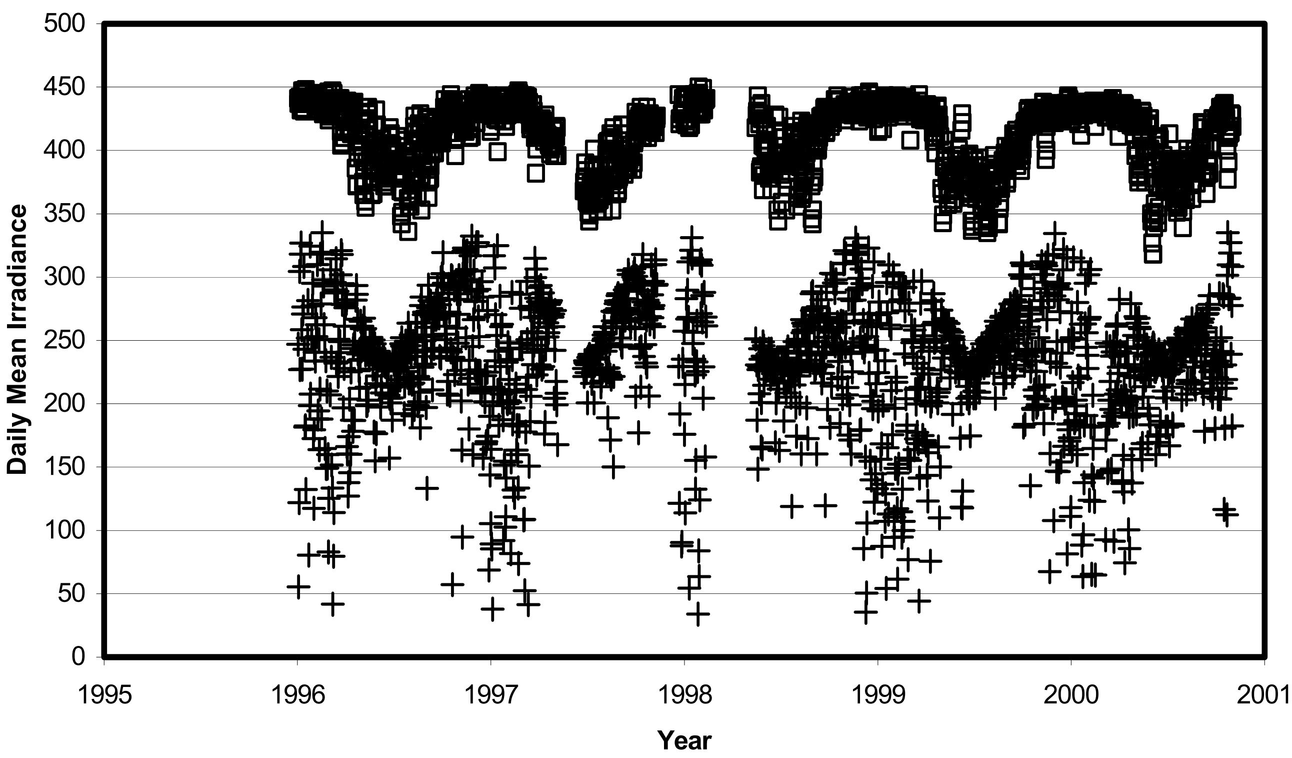

Figure 2. Daily mean solar and terrestrial irradiance at Darwin since December 1995, with the + being the global solar irradiance, and the boxes the terrestrial irradiance.

Darwin is the site of a World Meteorological Organization (WMO) Regional Meteorological Center. It consists of a full forecast office of some 90 staff with a supporting technical maintenance group. The office is responsible for forecasting and warning services throughout Northern Australia and over the maritime continent. Routine analyses and forecast products are produced covering the domain 20°S - 40°N and 90°E - 180°E. A full program of twice per day rawinsonde soundings and four per day wind soundings and supporting observations are conducted by trained staff from Darwin Airport (manned 22 hours per day). A full S-Band receiving facility is used to receive six hourly Advanced Very High Resolution Radiometer (AVHRR) data.

The Bureau of Meteorological Research Center (BMRC) (Keenan and Manton 1996) has supported a range of ground validation activities in Darwin in conjunction with the Australian Bureau of Meteorology's (BoM's) Northern Territory Regional Office (NTRO) since 1988 in support of the Tropical Rainfall Measuring Mission (TRMM). Darwin is one of the three primary TRMM GV sites.

The observational network for these activities is shown in Figure 3. Significant infrastructure is evident enhancing the NTRO network. The BMRC C-Band CPOL polarimetric radar is located at Gunn Point

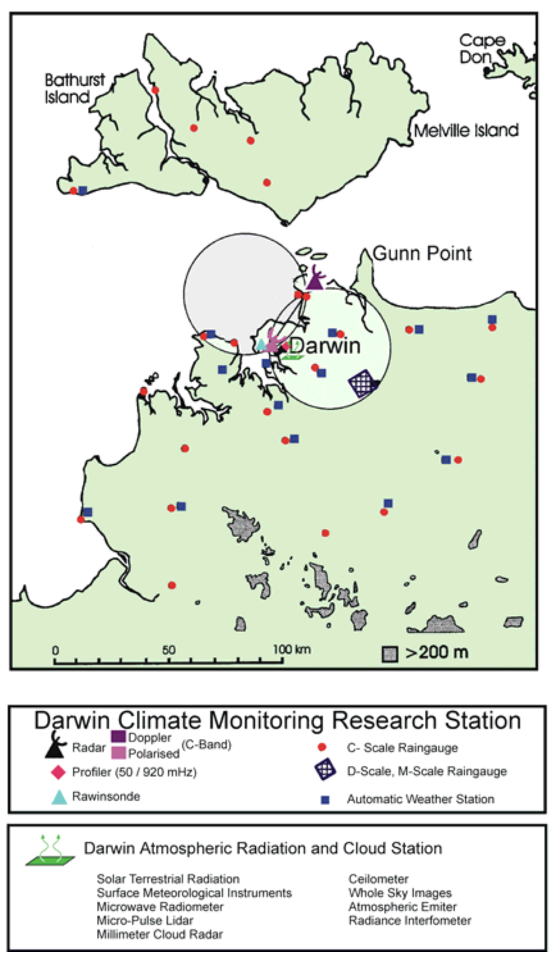

Figure 3. BMRC observational network at Darwin used in support of TRMM GV activities.

and a second C-Band Doppler radar maintained but upgraded by BMRC to support research activities operates at Berrimah. The two radars provide continuous monitoring of the environment during the wet season. Dual-Doppler coverage is undertaken as required with a 30 km baseline. The polarimetric radar provides the capacity to obtain microphysical properties of precipitating and some non-precipitating clouds (Keenan 1999). The BMRC 50-MHz and the National Oceanic and Atmospheric Administration 920-MHz wind profilers enable almost continuous observations of the three-dimensional structure of the wind. In conjunction with the polarimetric radar, the wind profilers have been used for extensive studies of the microphysical characteristics of the tropical precipitation (May and Rajopadhyaya 1996, 1999; May et al. 2001). All automated weather station (AWS), rainfall and disdrometer data are archived with AWS data available in real time. Note that this means that long-term datasets are available.

The BoM has operated a radiation measurement station including global, diffuse, direct, longwave, and spectral radiometer measurements for the past several years. It is also deploying an ultraviolet B spectrometer. Commonwealth Scientific and Industrial Research Organization (CSIRO) are also operating aerosol optical and physical properties at several carefully chosen locations, such as Jabiru (255 km east of Darwin).

All this is in addition to the new Atmosphere Radiation and Cloud Station 3 (ARCS3) site. This makes Darwin one of the best-instrumented sites in the tropics and comparable to the Cloud and Radiation Testbed (CART) site in Oklahoma in terms of its extensive observational network.

The scientific objectives of the BoM/CSIRO involvement include the following:

- Long-term monitoring of the four-dimensional structure, evolution, and associated radiative properties of coastal, maritime, and continental tropical cloud systems.

- Formulating and validating model parameterizations for numerical weather prediction and climate applications.

- Assessing the importance of the vertical structure of aerosol transport at Darwin using the combination of the micropulse lidar and sun photometry on the retrieval of aerosol products.

- Assess the importance of thin cirrus clouds on aerosol retrievals.

An example of a dual Doppler retrieval of air motion within a cloud system is given in Figure 4. This kind of observation together with the detailed cloud information available make observations that are unique opportunities. The C-Pol radar is also operating in a cloud-sensing mode giving an effective extended facility.

Experiments including aircraft in situ and airborne lidar measurements are also planned for November 2002. The aim is to document the microphysical characteristics of cirrus using a combination of ground-based measurements including the Atmospheric Radiation Measurement (ARM) ARCS3 instruments. The plan also includes lidar depolarization measurements using the airborne lidar of the

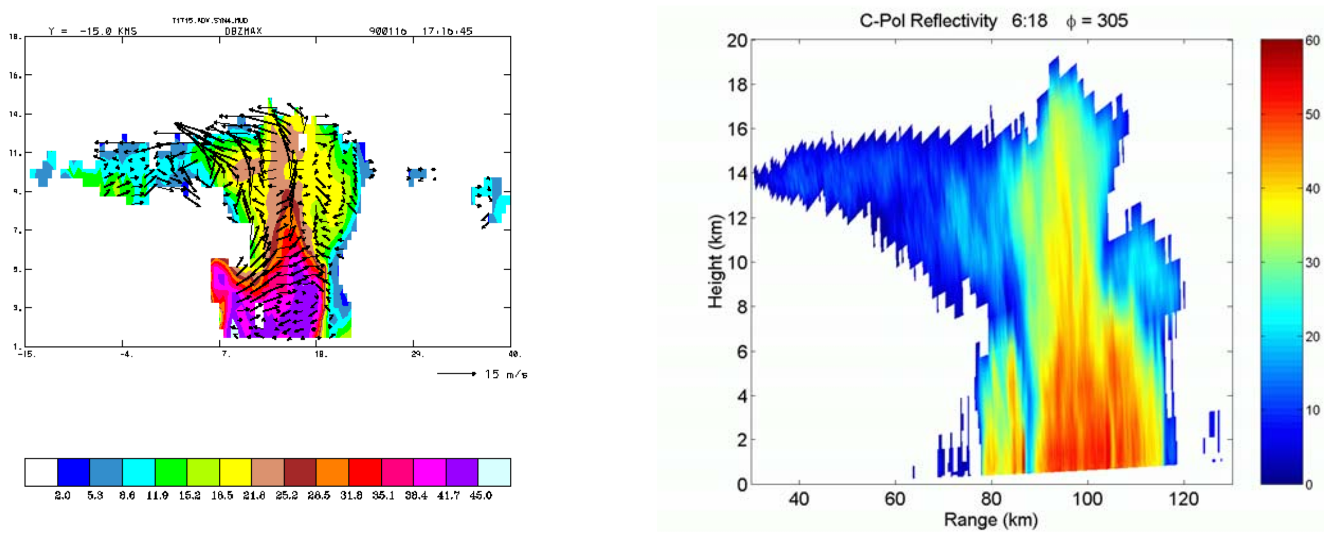

Figure 4. Dual Doppler retrieval of air motion within convection showing transport into the anvil and a return flow circulation in the lower part of the anvil (left) and a cross section through a "Hector" storm over the Tiwi Islands north of Darwin showing echo tops above 19 km (right).

University of Wales and in situ cloud measurements. Particular interest will be on cirrus originating in very deep continental/coastal convection. Storm tops exceeding 18 km high (e.g., see Figure 4) are often seen in the region near Darwin and over the Tiwi Islands.

We are also developing datasets including the other Tropical Western Pacific sites for use in model evaluation and testing. Hourly samples of all available ARM observations, "translated" into model variables (e.g., radiative fluxes; TCWV; profiles of T,q,u,v; cloud occurrence; cloud fraction; cloud boundaries) as well as external data are being prepared for this activity. These data are hourly where available and data such as sonde ascents will be the best available. These data are initially being prepared for Manus Island and Nauru, and Darwin data will be added as it becomes available.

There are clearly many opportunities for ARM scientists. The BoM datasets are all freely available.

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References

Keenan, T. D., 1999: *Preprints 29th International Conference on Radar Meteorology*, American Meteorological Society, 184-187, Montreal, Canada.

Keenan, T. D., and R. E. Carbone, 1992. *Q. J. R. Meteorol. Soc.*, **118**, 283-326

Keenan, T. D., and M. J. Manton, 1996: *BMRC Research Report*, **53**, p. 31, Bureau of Meteorological Research Center, Melbourne 3001, Victoria, Australia.

May, P. T., and D. K. Rajopadhyaya, 1996. *Mon. Wea. Rev.*, **124**, 621-633.

May, P. T., and D. K. Rajopadhyaya, 1999. *Mon. Wea. Rev.*, **127**, 1056-1071.

May, P. T., A. R. Jameson, T. D. Keenan, and P. E. Johnston, 2001: A comparison between polarimetric radar and wind profiler observations of precipitation in tropical showers. *J. Appl. Meteor.*, **40**, 1702-1717.