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The Restoration of CP2 in Brisbane, Australia

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1 Introduction

The Australian Bureau of Meteorology Research Centre (BMRC) has acquired the CP2 weather radar under the auspices of a joint project with the National Center for Atmospheric Research (NCAR) for the purposes of hydrometeorological research activities within Australia. As described by Keeler et al, (1989), CP2 was first built in the 1970's for hail and precipitation research in the National Hail Research Experiment undertaken in Colorado. Although CP2 has not been employed for a number of years in atmospheric research it remains a unique system with a dual wavelength (S and X band) and polarimetric/Doppler capability. To this end it has significant potential to still contribute to a number of significant research activities even thirty years after it was first in operation. For instance, measurement of the differential propagation phase shift (Φ_{dp}) at S-band was never implemented on CP2 so the potential measurement of both X-band attenuation and S-band differential propagation shift along the same path did not occur. Such a capability makes it possible to separately estimate rain and wet ice attenuation. To date the combination of dual frequency and dual-polarimetric radar has not been explored extensively in the research and especially the operational radar community.

This project aims to make use of the unique characteristics of the CP2 radar and builds on past joint activities between BMRC and NCAR. The project involves scientific and engineering contributions from both groups with emphasis on outcomes related to the nowcasting of severe weather, hydrology and weather impacting the aviation terminal area. Collaborative research is also planned with other groups including Colorado State University (CSU).

Although CP2 will function as a state-of-the-art dual frequency Doppler/polarimetric weather radar, designed primarily to aid atmospheric research it will also provide real time weather information to forecasters as required. In this manner the facility will be employed as meteorological testbed for nowcasting related applications required by the Bureau of Meteorology.

2 Proposed Research Activities

Expected outcomes from the joint research and development activities include:

- Improved Quantitative Precipitation Estimation (QPE) based on radar and in-situ measurements
- Improved understanding of precipitation processes with emphasis on orographic rainfall
- Improved Quantitative Precipitation Forecasting (QPF) for nowcasting (0-3 hour based on radar) and very short range forecasting (0-24 numerical weather prediction NWP)
- Improved hydrological modelling based on radar and NWP techniques
- Regional hourly rainfall accumulations, 100 km scale
- Development of urban 5-10 min flash flood forecasts
- Improved nowcasting of convection and severe weather including occurrence of hail, low level windshear, damaging downbursts, lightning, hydrometeor particle identification
- Diagnosis of the vertical profile of low level wind
- Diagnosis of the spatial structure low level refractivity with emphasis on moisture
- Development of NWP data assimilation techniques based on radar data
- Establishment of verification procedures in QPE, QPF and nowcasting

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3 Location and Climatological Regime for the CP2 Facility

CP2 will be located at Redbank Plains (Latitude 27°40.0' S Longitude 152°51.5' E) near Brisbane, Australia in a subtropical environment on the coastal zone of eastern Australia. As shown in Fig. 1, this coastal zone is flanked some 30-100 km to the west by complex ranges which rise over 1000 m in elevation. Interaction between the subtropical flow and the topography is an important factor in determining the local climate and associated potential weather related threats. Catchments and river valleys within the coastal ranges have significant potential for flooding. This includes the Brisbane flood plain inundated extensively in 1974

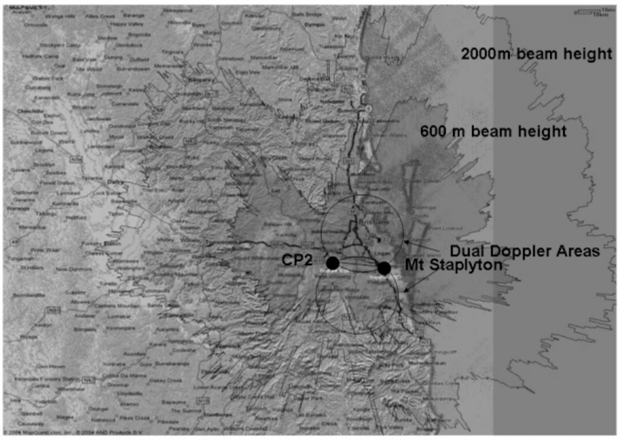

Fig. 1. Topography, surrounding environment and range where the CP2 beam height (m) intersects various levels. Dual Doppler lobes available using the Mt Stapylton Doppler radar and CP2 are indicated.

For the Greater Brisbane area, the average annual rainfall varies from around 800-900 mm on the southwestern plains to over 1600 mm on the highest peaks of the D'Aguilar range. Hence orographic enhancement of rainfall is significant. Rainfall is highest in January through to March when monthly averages range from around 120 mm at Ipswich to more than 250 mm at the top of Mt Glorious. Daily rainfall totals can be high during summer. Minimum rainfall is observed in August and September. The thunderstorm season for Southeast Queensland is mainly October through to April and there are about 20 days each year when severe thunderstorms occur. Approximately 30 percent of severe storm days involve significant hail.

The surrounding hills provide significant blocking and have significant impact on the CP2 coverage as indicated in Fig.1. However, key catchments affecting the Brisbane area are covered and with the operational S-Band Doppler radar located at Mt Staplyton dual Doppler lobes cover the high impact zones over Brisbane (significant flooding potential) and the highly populated Gold Coast to the south.

4 Existing Infrastructure and Observations

The Bureau of Meteorology, along with the Brisbane City Council, the Queensland Department of Natural Resources, and other catchment organizations operate about 220 stations providing continuous real time rainfall observations (at 1 mm resolution) from about 190 sites and water level data for about 140 sites. There is a network of 150 daily rain gauges within 150 km of Brisbane that provide additional; data each month to the Climate Data Base. A network of 15 telemetered mesonet stations operate within 150 km of Brisbane to provide temperature, humidity, pressure, wind, and rainfall measurements at hourly intervals. Upper air wind profiles are measured at 6-hourly intervals and upper air temperature and humidity profiles are collected at 12-hour intervals from Brisbane airport. The new operational S-Band 1^0 Doppler radar located at Mt Stapylton (see Fig. 1) provides additional quantitative radar data for the Brisbane area and with CP2 forms the basis for a dual-Doppler network. A Lightning Position and Tracking System (LPATS) technique as used in the USA and many other countries provides the position, polarity and intensity of cloud and ground strokes.

Importantly for the development of end-to-end forecasting processes and systems the Queensland Regional Forecast Centre is based in Brisbane. Its function is to deliver real meteorological and hydrological services to the local community and there is considerable existing meteorological and hydrological expertise and significant technical support. This office has high-speed data links to the Bureau of Meteorology national infrastructure and has access to the full suite of analyses and numerical model products that are generated routinely.

5 Technical Characteristic of the CP2 Facility

The technical characteristics of CP2 are described by Bringi and Hendry (1990) and summarized in Table 1. Further details of CP2 are summarized by Keeler et al. (1984) and the three co-aligned antennae configuration is shown in Fig.2.

Table 1. Technical Characteristics of the CP2 radar.

Characteristic	CP2 S-Band	CP2 X-Band
Wavelength (cm)	10.7	3.2
Peak Power (kW)	1200	200
Pulse length(μs)	0.15-1.2	1.0
PRF (s^{-1})	<1700	<1000
Antenna Type	Centre feed paraboloid	Two cassegrain paraboloids
Feed Type	Potter horn	Rectangular waveguide
Beamwidth (^{0})	0.93	0.94
Azimuth coverage (^{0})	360	360
Elevation Coverage (^{0})	90	90

Polarisations radiated	LIN H, LINV	LIN H
Simultaneous 2 channel reception	No	Yes
Polarisation Received	Copolar to TX	LIN H & LIN V
Max Sidelobe level (dB)	-21	~-30
Max Antenna Linear X-POL lobes (dB)	-21	-36
Polarisation Control Method	Ferrite Switch	NA
Polarisation Control rate	Pulse by pulse	NA
Channel to Channel Isolation (db) ex Antenna	>30	>30
Doppler Capability	Yes	No
Number of Range Gates	1024	1024
Range Resolution (m)	>30 typically 150	>30 typically 150
Polarisation Quantities measured	Z_{HH}, Z_{DR}, Φdp, ρ_{HV}	Z, L_{DR},

As summarized above CP2 is capable of measuring Doppler velocity and dual-frequency reflectivity at S and X-Band along matched beams. Polarimetric variables are also derived at S and X-band.

The CP2 system has been subjected to major refurbishment work at NCAR. As part of the joint activities all drive gearboxes were refurbished, a new transmitter focus coil assembly power supply were installed, along with a new ceramic thyatron with associated solid state trigger drive circuitry. Following system acceptance tests CP2 was shipped to Australia for installation with spare modules and components for all updated systems. A modern digital receiver and signal processing system is to be employed based on the NCAR PIRAQ III signal processing unit along with a new antenna control and data display system as shown schematically in Fig.3.

6 Proposed Site Infrastructure

The site for the radar will comprise the radar antenna and pedestal installed on a concrete foundation with a pressurized inflated fabric radome as shown in Fig.4. The thirteen tonne (plus) antenna structure requires significant reinforced concrete foundations on stable ground. The radome must remain pressurized at all times and this is maintained by a primary air blower with a second higher capacity blower used to add extra pressurization in the event of high winds. The receiver and transmitter are located underneath the pedestal along with office space. This configuration minimizes waveguide runs and subsequent losses. Communications to the facility will be in the form of normal telephone and high speed internet access (256-512kbs) to provide control of the radar and transmission of various data and products.

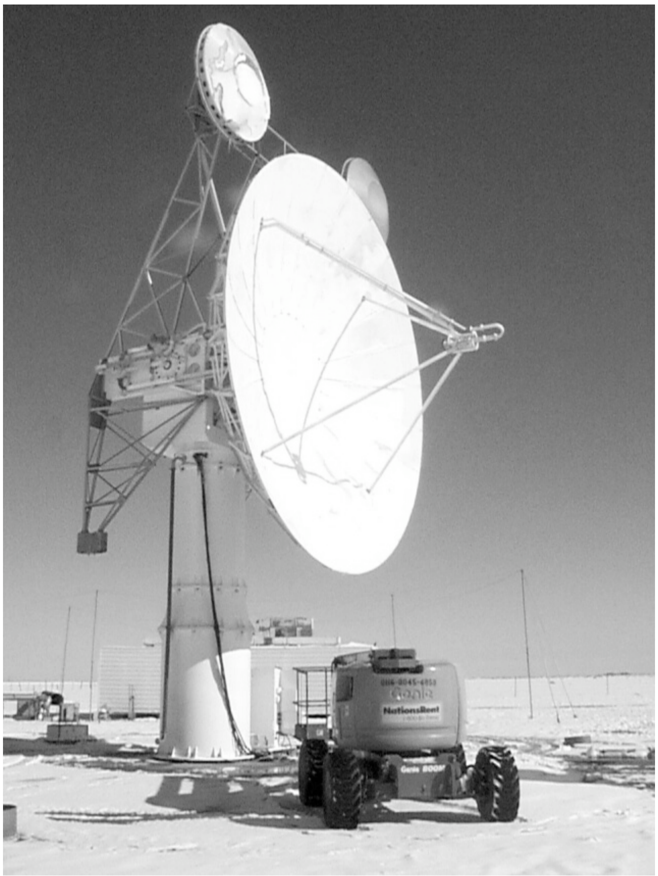

Fig. 2. CP2 pedestal and antenna during testing at Boulder. Two X-Band cassegrain paraboloids are located above the primary centre fed S-Band paraboloid dish.

The CP2 radar is a one-off radar facility for Australia and as such it is intended that spare parts and components will be located at the radar facility, hence the building includes a significant storage area.

The CP2 facility will be supported by dedicated BMRC technical support that will visit the site regularly for routine maintenance and repairs.

7 Summary

The revamped CP2 facility site works will be completed in August with the radar operational by November, 2006.

A key result of this project will be the development of products and end-to-end systems; that is taking the raw radar and providing product generation for evaluation by end users.

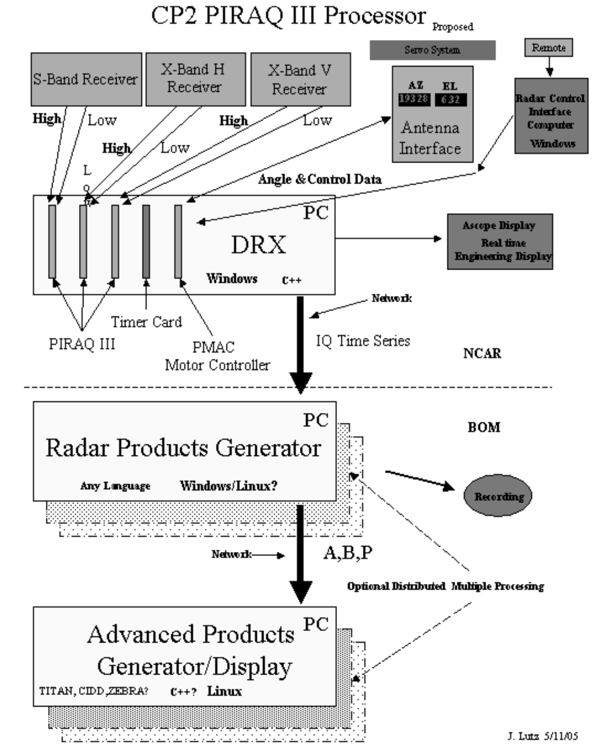

Fig. 3 Simplified schematic of updated CP2 signal processor, control, product generator and display systems.

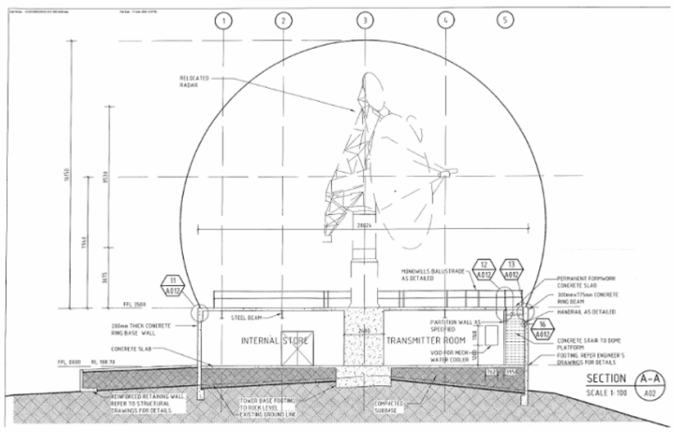

Fig. 4. CP2 site infrastructure. Antenna and pedestal within an inflated radome are mounted over housing for office, storage and transceiver.

In this context the end user is not restricted to the forecasters and hydrologists, but involves experienced weather and hydrological service clients.

For hydrological applications the initial focus will be producing high quality rainfall analyses and forecasts, and applying these data in a probabilistic framework to a suite of hydrological models to produce flood warning products. Real-time verification will also be an important component.

More traditional weather related products will be developed and tested by the Bureau in collaboration with other organisations. In this sense CP2 is seen as testbed for the development, testing and intercomparison of algorithms before operational use by the Bureau of Meteorology. Again the key is end-to-end systems. Processes and products will be interfaced with the Bureau operational systems to enhance the overall forecast process.

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