12B.1 RATIONALE AND USE OF THE CP2 TESTBED IN BRISBANE, AUSTRALIA

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1. INTRODUCTION

The Australian Bureau of Meteorology Research Centre (BMRC) has acquired the CP2 weather radar as part of a joint project with the National Center for Atmospheric Research (NCAR) for the purposes of hydrometeorological and nowcasting research within Australia. CP2 was first built in the 1970's for hail and precipitation research as part of the National Hail Research Experiment as described by Keeler et al, (1989). Although CP2 has not been employed for a number of years the unique dual wavelength (S and X band) and polarimetric/Doppler capability retains significant capability. For instance, measurement of the differential propagation phase shift (Φ_{dp}) at S-band was never implemented on CP2. Measurement of both X-band attenuation and S-band differential propagation shift makes it possible to separately estimate rain and wet ice attenuation. To date the combination of a dual frequency and dual-polarimetric radar has not been explored extensively in the research and especially the operational radar community.

This project builds on the unique characteristics of the CP2 radar and 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 research weather radar, it will also provide real time weather information to forecasters in an operational mode. In this manner the facility will be employed as meteorological testbed for nowcasting related applications required by the Bureau of Meteorology.

2.0 PROPOSED RESEARCH ACTIVITIES

Expected activities from the joint research and development activities include:

- Improved Quantitative Precipitation Estimation (QPE) based on radar and in-situ measurements
- Improved understanding of orographic precipitation processes
- 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
- Development of urban 5-10 min flash flood forecasts
- Support for cloud seeding studies in SE Queensland
- 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
- End-to-end nowcasting service development with associated impact studies

3.0 LOCATION OF CP2

CP2 is now 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. This coastal zone (see Fig.1) is flanked some 30-100 km to the west by complex ranges which rise over 1000 m in elevation. Interaction between the low-level south-easterly subtropical flow and the topography is an important factor in determining the local climate and associated weather related threats. Catchments and river valleys within the coastal ranges have significant potential for flooding.

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. 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 impact the effective CP2 coverage as indicated in Fig.1. However, key catchments affecting the Brisbane area are monitored and with the operational S-Band Doppler radar located at Mt Staplyton, dual Doppler lobes cover important zones near Brisbane with significant flooding potential. The rapidly developing and highly populated Gold Coast to the south is also covered by CP2.

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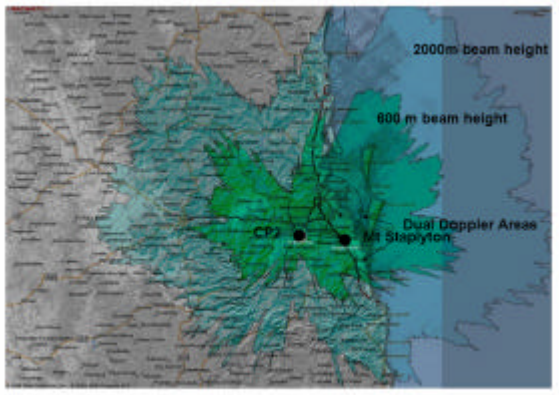


Figure 1. Topography, surrounding environment and range where the CP2 beam height (m) intersects various levels. Dual Doppler lobes available using the Mt Stapylton Doppler radar and CP2 are indicated.

4.0 INFASTRUCTURE AND SUPPPORTING OBSERVATIONS

The Bureau of Meteorology, along with the Brisbane City Council, the Queensland Department of Natural Resources, and other catchment authorities operate

- 220 stations providing continuous real time rainfall observations (at 1 mm resolution) from about 190 sites
- Water level data from about 140 sites
- 150 daily rain gauges (within 150 km of Brisbane)
- 15 telemetered mesonet stations operate (within 150 km of Brisbane)
- A Lightning Position and Tracking System (LPATS) provides the position, polarity and intensity of cloud and ground strokes
- Upper air wind profiles at 6-hourly intervals and upper air temperature and humidity profiles at 12-hour intervals.

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.

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.

Figure 2. CP2 pedestal and antenna pictured during installation at Redbank Plains. Two X-Band cassegrain paraboloids are located above the primary centre fed S-Band paraboloid dish.

5.0 TECHNICAL CHARACTERITICS OF CP2

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

The CP2 system was 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 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.

The site for the radar comprises 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

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	>30 typically	>30 typically
Resolution (m)	150	150
Polarisation Quantities measured	Z_{HH}, Z_{DR}, Φdp, ρ_{HV}	Z, L_{DR},

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 (1Mbs) to provide control of the radar and transmission of various data and products.

The CP2 radar is a one-off radar facility for Australia with spare parts and components located at

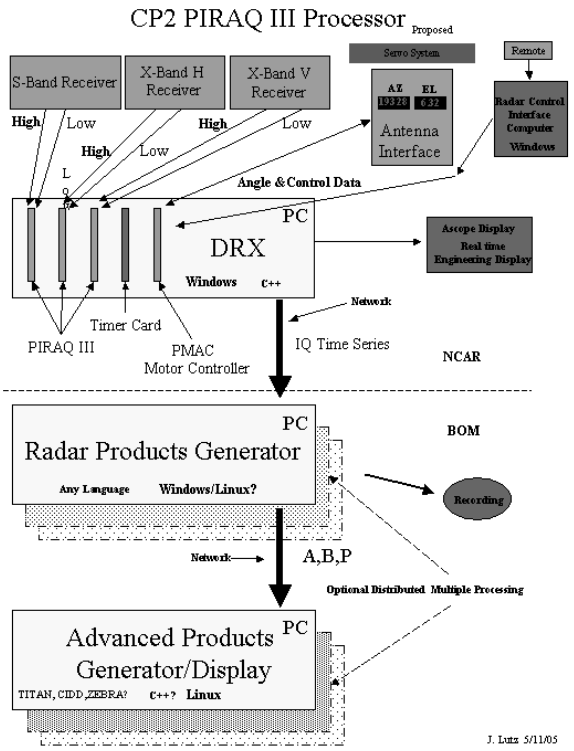
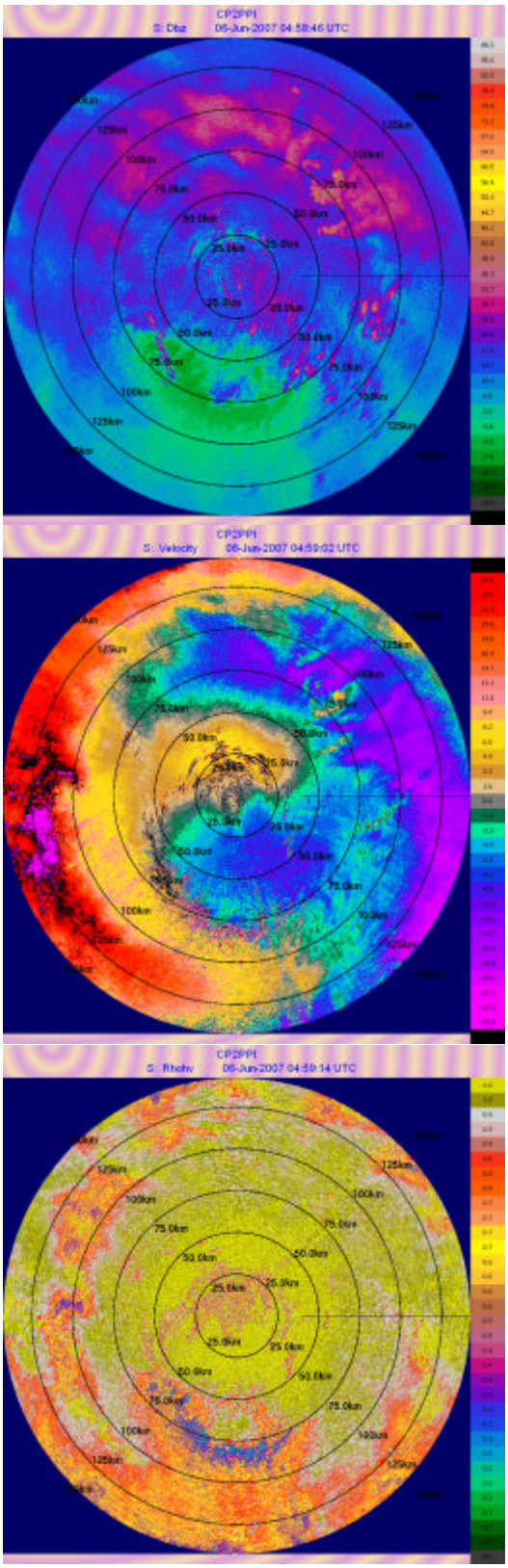


Figure 3. Simplified schematic of updated CP2 signal processor, control, product generator and display systems.

the radar facility, hence the building includes a significant storage area. The CP2 facility is supported by dedicated BMRC technical support that visits the site regularly for routine maintenance and repairs.

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

The revamped CP2 facility site works were completed nearly 2007 with the radar providing initial results in June 2007 as shown in Fig. 5. The first routine operation of CP2 will be beginning in August 2007 supporting hail and cloud seeding studies in SE Queensland.



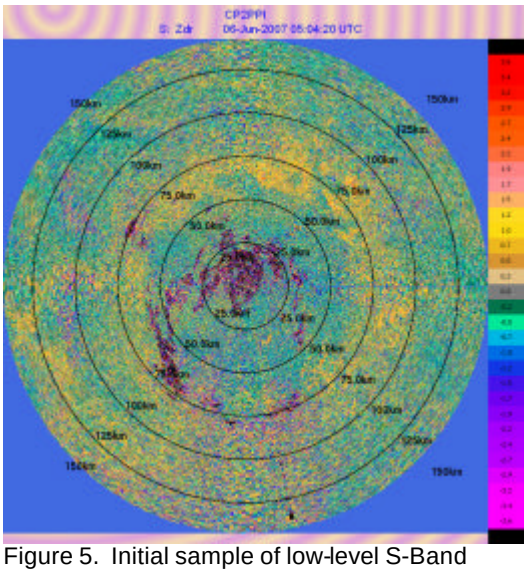


Figure 5. Initial sample of low-level S-Band polarimetric variables observed by CP2 at Redbank Plains. In this case negative radial velocities are away from the radar.

6.0 SUMMARY

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.

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.

Acknowledgements

Support for this project was provided by the Bureau of Meteorology and with the cooperation of the National Science Foundation, USA.

7.0 REFERENCES

Bringi, V.N. and A. Hendry, 1990: Technology of Polarisation Diversity Radars for Meteorology, Chapter 19A, *Radar in Meteorology*, Edited, D. Atlas, American Meteorological Society, 806pp.

Keeler, R.J., P.H. Herzegh and C.L. Frush, 1984: Measurements of CP2 copolar and cross-polar antenna illumination functions at S and X-Band. Preprints, *22nd Radar Meteorology Conf.,* Zurich, Amer. Meteor. Soc., 287-291

Keeler, R.J., B.W. Lewis and G.R. Gray, 1989: Description of NCAR/FOF CP-2 Meteorological Doppler Radar. Preprints, *24th Radar Meteorology Conf.,* Tallahassee, Florida, Amer. Meteor. Soc., 589-592