

# Synergetic use of MMCR and C-Pol radars for retrievals of cloud and rainfall parameters



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## Objectives

To develop a technique for simultaneous retrievals of cloud and precipitation parameters (rain rate,  $R$ , rain water path, RWP, cloud liquid and ice water paths – CLWP and IWP) with instrumentation currently available at the Darwin ACRF. To assess applicability of the technique to different events and to estimate potential retrieval errors.

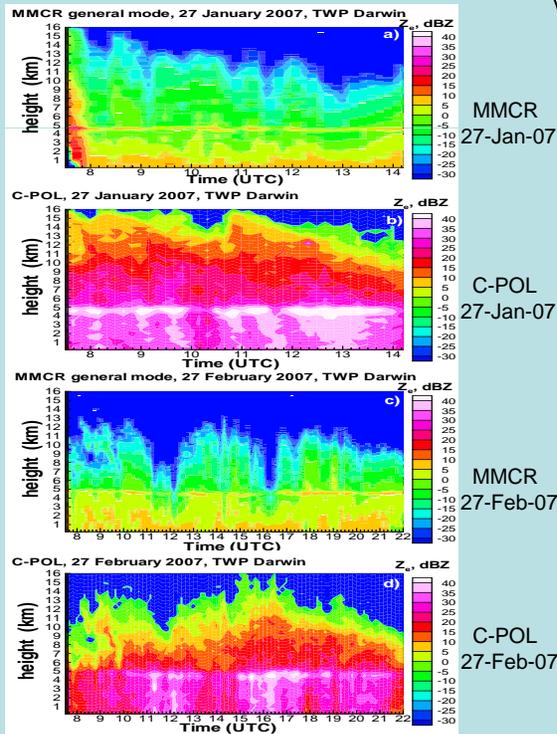
## Approach

Radar bright band separates hydrometeors of liquid, mixed and ice phases. C-POL data are used to get vertical changes of non-attenuated reflectivities and to calculate vertical profile of  $R$  (with disdrometer constraints). Vertical gradients of MMCR reflectivity with C-POL derived  $R$  information are then used to estimate CLWP. IWP values are derived using C-POL measurements.

## Conclusions

Simultaneous retrievals of cloud and rainfall parameters in the vertical atmospheric column are possible at the TWP Darwin ACRF with currently available instrumentation (MMCR, C-POL, JWD). Retrievals, however, are limited to light-to-moderate stratiform events and errors are high (especially for CLWP). Use of new radars (e.g., SWACR) can improve accuracies.

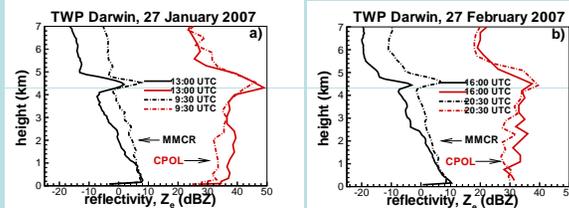
## Examples of radar measurements



General mode MMCR measurements (a) and (c) and RHI C-POL measurements (b) and (d) for two Darwin ACRF stratiform precipitation events observed in 2007. Note lower cloud tops and high attenuation at  $K_a$ -band, Higher reflectivities and lower resolutions at C-band.

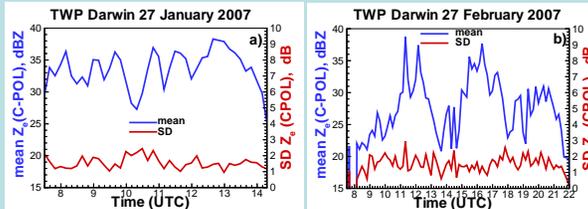
Acknowledgement: C-POL data were provided by CAWCR researchers (M. Whimpey, P. May, and A. Protat)

## C- and $K_a$ -band reflectivity profiles



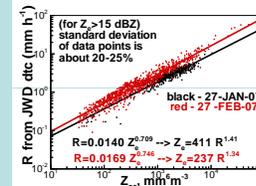
Simultaneous vertical C-POL and MMCR vertical profiles of reflectivity (low variability of C-band Z values and steep vertical gradients of  $K_a$ -band reflectivity due to attenuation caused by liquid water clouds and rain co-existing below BB

## Vertical variability of C-band reflectivities

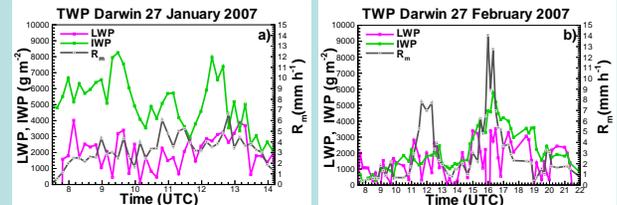


In stratiform rainfall, non-attenuated reflectivity varies very modestly. Typical variabilities are within 1-2 dB (see above). C-POL reflectivities corrected by differential phase are used in the retrieval method as proxy for non-attenuated Z values, so the vertical changes in MMCR reflectivities solely due to attenuation can be inferred.

## Retrieval results

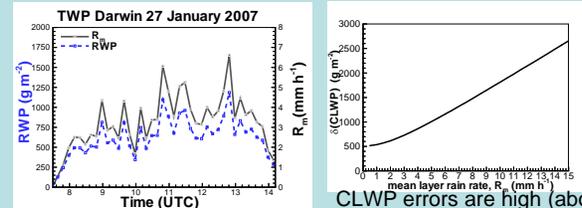


Rain rate profiles are calculated using C-band Z-R relations from form JWD data for each event. C-POL Z data are constrained at the surface by reflectivities from JWD DSDs. JWD data are verified by gauge measurements.



Retrievals of CLWP are performed using MMCR reflectivity gradients (after accounting for gaseous and rain attenuation). IWP retrievals are performed using Z-IWC relations and C-POL measurements corrected by differential phase and constrained by the JWD measurements.

## Retrieval errors



Mean layer rain rate can be re-calculated in terms of RWP.

Z-based estimates of IWP can have uncertainties of about 60%-70%.