

**SUSTAINABILITY, ENVIRONMENT, WATER, POPULATION  
AND COMMUNITIES PORTFOLIO**

Ref: B12/1752

To: Parliamentary Secretary for information  
Cc: Minister  
Cc: Secretary; Deputy Secretary, David Parker

**REDBANK RESEARCH RADAR REPAIRS**

**Timing:** 26 October – preparation for possible interest following media story

**Recommendation/s:**

1. Note the research radar upgrade and repair history; and
2. Note the associated talking points.

**Noted / Please discuss**

**[Signatory]:**

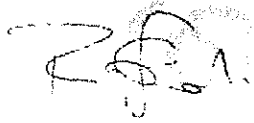
**Date:**

**Comments:**

**Key Points:**

1. The Bureau of Meteorology participated in the installation of a specialist research weather radar facility near Ipswich, Queensland in collaboration with the US National Center for Atmospheric Research (NCAR). The research program commenced in 2007. The Bureau investment was a one off approximately \$2.5 million with a small ongoing investment to support the research.
2. The radar is not configured for, nor is it required for, operational forecasting as the area is already well served by radars including those at Mt Stapylton (an advanced high resolution Doppler radar) and Marburg.
3. The Redbank research radar was based on the NCAR CP2 system that had been used for some time, but had extensive technological upgrades to make it a state of the art facility.
4. The radar was announced in media releases on December 2006 and September 2007 (Attachment A).
5. The radar performed its research function successfully until March 2009 after which a series of major equipment failures and international trade requirements have delayed both its repair and upgrade (see Attachment B).
6. Subject to suitable weather, the radar is scheduled to be repaired by the end of 2012 or early next year in order to commence the next phase of the research program to scientifically measure some severe weather systems this coming season.
7. The radar's research program will eventually deliver new products and applications for forecasters but the research is still being undertaken in the international collaboration with the USA (Attachment C).

8. Information from this radar will increase scientists understanding of thunderstorms and cloud systems that will lead to a wide variety of improvements to products and applications.
9. The radar is a key component of planned international programs including NASA funded activities associated with the upcoming Global Precipitation Measurement Mission.
10. Channel 7 news stories in Brisbane on the evenings of Wednesday 24 and Thursday 25 October 2012 highlighted the length of time taken to repair the radar. This is fundamentally because it is a stand-alone research system that requires specialist skills and equipment in its repairs. Our operational radars have a significantly shorter repair time (days to weeks as a maximum).
11. This was advised to Channel 7 prior to their report but apparently ignored.
12. Proposed talking points are attached (Attachment D)



Dr Ray Canterford  
Acting Director  
Bureau of Meteorology  
Ph: [REDACTED]  
Mob: [REDACTED]  
[26 / 10 / 2012]

Dr Peter May  
Deputy Director  
Centre for Australian Weather and Climate  
Research  
Ph: [REDACTED]  
Mob: [REDACTED]

Under FOI

**ATTACHMENTS**

**A:** Research Radar - Media releases – December 2006 and September 2007

**B:** Research Radar – Construction, Upgrade and Repair

**C:** Research Program Overview

**D:** Research Radar - Upgrade and Repair – Draft talking points

Released Under FOI

Research Radar - Media release – December 2006



**Australian Government**

**Bureau of Meteorology**

GH06/159

**QLD RADAR TO BENEFIT STORM FORECASTING**

Australian storm forecasting will benefit from a Bureau of Meteorology research weather radar nearing completion near Redbank Plains in southeast Queensland.

Parliamentary Secretary with ministerial responsibility for the Australian Bureau of Meteorology, Greg Hunt, said the radar is of enormous significance.

"It is the only one of its type in the world," Mr Hunt said.

"It offers unique capabilities to complete weather research and support development of new forecasting techniques for severe weather, aviation and hydrological forecasting purposes.

"It will operate from March 2007 and will also be available for operational forecasting.

"This \$2.5 million dual frequency polarimetric weather radar places Australia at the forefront of research in this important area.

"The coverage from the 20-metre tall structure on Mt Juillerat, 9km southeast of Ipswich, is designed to overlap that of the new Doppler weather radar installed at Mt Staplyton."

The CP2 research facility built by the National Center for Atmospheric Research in the USA comprises two radars operating at different frequencies.

By differentiating between rain, hail and various mixtures of ice and water, it improves rainfall estimates within a storm, and detects severe weather threats associated with hail and other phenomena.

The Bureau chose South East Queensland because it was typically affected by 10 severe storms a year, with significant potential for intense rainfall and local flooding in this fast-growing region.

This is a joint project between the Bureau of Meteorology and the US National Center for Atmospheric Research.

More information: [www.bom.gov.au/bmrc/wefor/projects/radar/CP2\\_Radar.htm](http://www.bom.gov.au/bmrc/wefor/projects/radar/CP2_Radar.htm)

**Media Contact:**

John Deller (Mr Hunt's Office) on [REDACTED]

# Media Release

**THE HON JOHN COBB MP**

**Assistant Minister for the Environment and Water Resources  
Member for Parkes**

Thursday, 27 September 2007

## **New research radar for South East Queensland**

South East Queensland will benefit from a state-of-the-art research weather radar commissioned today at Redbank Plains near Ipswich. It is expected to be online by summer.

The new radar – called a CP2 radar – will support research into storms affecting Brisbane, the Gold and Sunshine Coasts, Toowoomba, and the Eastern Darling Downs. The CP2 radar has the ability to undertake detailed measurements of storms including more accurate measurement of rainfall and hail using Doppler, polarimetric and dual frequency methods.

The new radar is unique in Australia and provides a significant boost to Australia's capability to undertake storm research and to develop and improve meteorological and hydrological forecasting systems.

The Assistant Minister for the Environment and Water Resources, the Hon John Cobb, said that the new radar will provide benefits through increased understanding of the frequent intense storms that affect the rapidly developing area of South East Queensland.

"The new CP2 radar will allow the evolution of intense storms to be studied as they develop over the south east corner of Queensland and it will provide a welcome focus for ongoing research and development work for national and international partners," Mr Cobb said.

"The unique research and data capabilities of the CP2 radar will when combined with the Mt Stapylton radar allow unprecedented detail to be revealed of the evolution and structure of storms in the Brisbane area."


"With its new capabilities the CP2 radar will be an important addition to Bureau capability to undertake research into rainfall and precipitation processes and develop improved very short term forecasting techniques," Mr Cobb said.

"This is a new \$2.5 million investment in upgrading weather radar technology for research. This investment will improve the utilisation of radar information in the development of Australia's weather services."

In its first year the facility will be employed for validation of satellite based rainfall measurements undertaken by NASA as part of the Tropical Rainfall Measuring Mission and in support of cloud seeding experiments undertaken by the Queensland Department of Resources and Water.

The CP2 radar was acquired by the Bureau of Meteorology under an agreement with the University Corporation for Atmospheric Research, Earth Observing Laboratory (EOL) in the USA.

### **Media information:**

Tom Chesson (Mr Cobb's office) 

## Research Radar – Construction, Upgrade and Repair

### Overview

#### Construction

- Construction began in April 2006
- The radar opened on 27 September 2007
- The replacement value of this radar hardware is approx. \$5.0million.
- The Bureau invested \$2.5million for the infrastructure around the radar facility.
- The base radar had previously been used in Colorado, USA
- Prior to installation the radar had major upgrades to bring it to state of the art capability including advanced signal processing.

#### Repairs - general

- During the past three years there have been two failures of the main bearing and an upgrade of the radar dish
- The time required to procure, manufacture, import and install these highly specialised pieces is significant.
- They are not 'off the shelf items'
- The bearing has to support more than twelve tonnes of weight, is about 0.66 metres in diameter and has to be constructed by an engineering firm capable of machining it to an accuracy of about a thousandth of a centimetre.

#### Repair and Upgrade - 2009-2011

- The main bearing first failed in March 2009
- An advanced antenna from its sister facility in Colorado was made available by Colorado State University (CSU) and the US National Science Foundation (NSF). Export of this took some time to obtain permissions for the export of the advanced antenna. This represents a continued significant investment by international partners in the facility
- The repairs and restoration of operations were completed on 9/9/2011

#### Repair - 2012

- The radar's main bearing failed on 1 February 2012
- It is now being replaced.
- The radar is expected to be performing its research function by the end of 2012.
- There is a wide range of research planned using this facility.

### Detailed history

Event	Date
<b>Construction</b>	
August 2004	Potential Radar Site at Redbank Plains identified
May 2005	CP2 Development Approval for Redbank Plains
March-April 2006	Contract to Build and building commenced
Dec 2006	Radar Dome First Installed
27 Sept 2007	CP2 Officially opened
<b>Research</b>	
August 2007	SEQCSRPs started
Nov 2007	CSRPs activities started
Nov 07 – Apr 08 Oct 08 – end Feb 09	CSRPs went for two seasons
<b>First break down</b>	
11 March 2009.	First failure of Azimuth Bearing
26 June 2009	Order placed with bearing manufacturer - lead time 22-24 weeks
Upgrade	<p>Following the initial bearing failure, discussions begun with CSU, NSF and NCAR to obtain a new antenna from the sister facility in Colorado.</p> <p>This was successful, but there were delays associated with gaining International Traffic in Arms Regulation (ITAR) export permission for the antenna (invoked by the US because of the antenna's advanced technological capability).</p>
27 June 2009	Negotiations on the Colorado State University (CHILL) Upgraded Dish
Sept 2009	Decision to Get the CHILL Dish
Nov 2009	CHILL Dish Export License started
5 Feb 2010	Bearings Delivered for first repair
29 Mar 2010	Shipping of the CHILL Dish started
18 June 2010	CHILL dish on site CP2
2 August 2010	Repairs Of CP2 & CHILL adding start
10 Aug 2010	Problems with New Bearings

Event	Date
20 Aug 2010	Bearing Repairs completed and back up with CHILL
23 Dec 2010	CP2 Dome back on (after many weather & contractor delays)
Feb 2011	Re-assembly under dome commenced
March 2011	CHILL Upgrade Waveguide components ordered
7 June 2011	Waveguide delivered
Early Nov 2011	All installed and radar operational again
<b>Second Break down</b>	
1 Feb 2012	2 <sup>nd</sup> Failure of Azimuth Bearing
14 Feb 2012	Summary of findings – FORGACS brought in
17 Feb 2012	Tender/quote to repair FORGACS - includes Automated greasing system upgrade
3 May 2012	Order to progress repairs placed (Long lead time for bearing manufacture)
11 Sept 2012	Dome Take down and repairs commenced
8 Oct 2012	New bearings received by Forgacs
26 October 2012	Work progressing.



### Research Program Overview

The CP2 radar was installed as a partnership with the US National Centre for Atmospheric Research and Colorado State University with National Science Foundation Support.

This radar remains one of the very few dual polarisation dual frequency radars in the world.

It is a key facility for international collaboration between the Bureau, Colorado State University (CSU), NCAR and NASA.

The first major program to use this facility was the SE Queensland Cloud Seeding Research Program involving NCAR, the Queensland Govt, the Bureau and Universities.

This program produced a major report and several research papers including several from the Bureau. An excellent Masters Thesis from Macquarie University was also undertaken using this data. (This thesis has produced two important papers on rainfall estimation with advanced radar in the open literature). More papers from this program are in preparation.

The radar continues to have key research applications including technological assessment for Bureau operations.

It is a key facility for international collaboration with Colorado State University and NASA funded research in support of the upcoming Global Precipitation Mission. This includes algorithm development, fundamental cloud physics and ground validation.

## Research Radar - Upgrade and Repair – Draft talking points

### *Radar Purpose*

- The radar is an important component in Australian and United States research projects associated with weather forecasting.
- The research will help develop products and applications for weather forecasters which integrate rainfall and satellite data.
- The radar is used for cutting edge research purposes and its output is not suited to forecasting operations.

### *Repairs - 2012*

- The radar's main bearing failed on 1 February 2012 and is now being repaired.
- The radar is expected to be performing research functions by the end of 2012, subject to weather.
- The bearing is a specialist item and is not available 'off the shelf'.
- The bearing has to support more than twelve tonnes of weight, is about 0.66 metres in diameter and has to be constructed by an engineering firm capable of machining it to an accuracy of about a thousandth of a centimetre.

### *Repairs and Upgrade -2009-2011*

- The radar had similar problems beginning in 2009.
- When the bearing failed it was decided to use the down time to also import a new upgraded radar dish from the United States.
- United States regulatory requirements significantly delayed the export of the dish to Australia.
- Following completion of the repairs and installation of the upgraded dish the radar returned to research activities in September 2011.
- Research activities continued successfully until the main bearing again failed on 1 February 2012.

**BUREAU OF METEOROLOGY**

**OVERSEAS VISIT REPORT  
(VISIT NO.                    )**

- 1     BRANCH HEAD
- 2     STIP
- 3     DEPUTY DIRECTOR
- 4     DIRECTOR

**OFFICER TRAVELLING**

Name           Peter May.....

AGS Number   [REDACTED] .....

Designation   .....ADRD, .....

Location       .....Collins Street.....

**MISSION**     Attend the 5<sup>th</sup> International Workshop of GPM Ground Validation,  
Toronto Canada, July 2012

**DATES OF DEPARTURE AND RETURN**

9-12 July 2012

**PURPOSE OF MISSION (as per Submission)**

The Global Precipitation Measurement (GPM) mission will launch its core satellite in 2014. GPM Core Observatory will carry an advanced radar-radiometer system to allow advanced precipitation observations from space. A series of international planning workshops are being held globally and GPM has established a framework for science collaboration to support pre-launch algorithm development and post -launch evaluation. It is important that the Bureau of Meteorology accept this invitation and progress in this field of science which plays an important role in forecasting extreme events. There has been a long and productive relationship with TRMM and GPM planning including strong interactions and visitors associated with this program. Both Darwin and Brisbane CP2 radar data have been used for validation, algorithm development and basic science supported by these programs. This is also an opportunity to bring the new capability for the RV Investigator to the attention of a key group. Contributions to these programs represent a significant Australian input into the international EOS program. The Bureau will benefit by continued interaction with this program and through recognition of Bureau contributions.

**EVIDENCE THAT THIS MISSION HAS CONTRIBUTED TO AND BENEFITED PROGRAM OBJECTIVES IN IDENTIFIABLE AND TANGIBLE WAYS**

This short meeting was discussing validation for the GPM mission. This follows the long interactions with NASA and partners, especially at CSU, on TRMM related work. There was also active interest at the meeting in the new research vessel and potential GPM related research using the dual pol radar being procured. This included potential field projects. There continues to be interest in the use of Bureau facilities and collaboration using Dawin (including the ARM site) as well as CP2 and applications using SREP output.

**OVERALL SUCCESS/VALUE OF MISSION *(see more detailed report attached)***

This was a productive and useful meeting. Our involvement with and support of these activities should also be communicated with the SPE as a Bureau/Australian space contribution.

***I AM AWARE THAT ACQUITTALS SHOULD BE MADE WITHIN 10 WORKING DAYS UPON RETURN FROM THE MISSION.***

**SIGNATURE.....DATE.....**

## SUMMARY REPORT

This workshop was the 5<sup>th</sup> in a series of international workshops in support of and preparation for the upcoming Global Precipitation Meeting. There were scientists from the UK, Europe, Japan, Korea, Brazil, Canada and the US attending this meeting.

As well as the scientific presentations, Thomas Piekutowski provided an overview of Canadian Space Agency activities. These parallel the Australian Space Policy Unit in many ways, but have a much larger staff and have made the strategic decision to partner with ESA and contribute instruments to planned missions. This has built satellite development capability in Canada as well as demonstrated contributions to the international program.

There was considerable discussion on strategies for validation including the separation of structural and retrieval errors, methodologies for physically based retrievals etc. This included discussion on the roles of modelling and observation in the algorithm development and the associated validation. Note that the use of polarimetric data provides far greater constraints than reflectivity only and that the uncertainties in validation data are

There was a presentation by Chris Williams, a regular collaborator and chair of the rain dropsize distribution working group (a key issue for radar and microwave retrievals of rainfall) that discussed the approaches for dealing with DSD variability and parameterisation. This work draws heavily on data collected from Darwin and the CP2 facility.

One of the key goals for GPM is to extend TRMM type capability to high latitudes. This is the one of the reasons for the dual frequency radar (in addition to the use of the two frequencies to constrain estimates of rain drop size distributions for more accurate rainfall estimation) and the addition of high microwave radiometer frequencies. Note the radar sensitivity is still low compared with Cloudsat, and will miss much of the snowfall. This means there is work being undertaken to use the GPM radars for high snowfall rates combined with extensions to low rates with the radiometers and algorithm development using Cloudsat and other A-train data. There is a potential Australian contribution with the snow fall estimation being undertaken by Snowy Hydro.

Ice and snow represents a particular challenge because of strong dependencies of radar reflectivity and microwave emission not just on size, but particle habit and density.

In my talk I discussed the Bureau research facilities as well as the new capability being deployed on the RV Investigator. There was considerable interest in this, notably from Walt Petersen who is coordinating the overall GV effort and Gerry Heymsfield who is leading cloud and precipitation missions using the NASA Global Hawk. Gerry is interested in potential observations in the Southern Ocean.

A report on the meeting will be published on <http://pmm.nasa.gov/meetings/all/5th-international-workshop-gpm-ground-validation> and presentations can be downloaded from: <http://www.5th-gpm-gv-workshop-2012.org/program.php>

Key outcomes was a recognition of the value of Bureau resources for algorithm development and validation. This includes the research facilities (Darwin, CP2 and RV Investigator) and

the group is keen to access data from our operational radar network including rainfields output. The important contributions made by Beth Ebert were also noted frequently during the meeting.

Released Under FOI

**Karen Hughes**

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**From:** Alain Protat  
**Sent:** Friday, 6 July 2012 14:43  
**To:** Peter May  
**Subject:** RE: GPM meeting [SEC=UNCLASSIFIED]  
**Attachments:** GPM GV Australia.pptx

**Security Classification:**  
 UNCLASSIFIED

Hi Peter,

I have (quickly) added three slides, let me know if that's OK with you. I did not talk about possible synergies with other satellite missions (except a little bit with MT) because I don't think we'll have the resources to do that.

When are you flying ? Saturday ?

Cheers,  
 Alain

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**From:** Peter May  
**Sent:** Thursday, 5 July 2012 11:37  
**To:** Alain Protat; Beth Ebert  
**Cc:** John Le Marshall  
**Subject:** RE: GPM meeting [SEC=UNCLASSIFIED]

That about sums it up I think. The opportunity associated with the dual F cloud radar -- what are your plans there?

Peter

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**From:** Alain Protat  
**Sent:** Thursday, 5 July 2012 11:27 AM  
**To:** Peter May; Beth Ebert  
**Cc:** John Le Marshall  
**Subject:** RE: GPM meeting [SEC=UNCLASSIFIED]

OK, I'll wait for your call.

So for the slides all you need is a list of work we are currently doing that is relevant to GPM ?

Regime dependence of rainfall  
 Your aerosol / precip work  
 Convective / stratiform separation  
 Mass-size relationships in tropical ice cloud systems  
 etc ...

And a list of facilities / products that will be available to the GPM community ?

ARM site  
 CPOL+operational weather radars  
 CP2  
 Ship C-band radar

Cheers  
 Alain

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**From:** Peter May  
**Sent:** Thursday, 5 July 2012 11:15

**To:** Alain Protat; Beth Ebert  
**Cc:** John Le Marshall  
**Subject:** RE: GPM meeting [SEC=UNCLASSIFIED]

Alain,

I will give you a call. The reality is we will have to badge work we want to do anyway as GPM related. This includes the work with Bringi (who is funded by NASA), but unless we have external funding we are a bit limited. We should have a discussion with the Space Policy Unit to see if they will fund any validation related research as part of Australia's contributions.

John – this is something we should discuss,

Peter

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**From:** Alain Protat  
**Sent:** Thursday, 5 July 2012 11:11 AM  
**To:** Peter May; Beth Ebert  
**Subject:** RE: GPM meeting [SEC=UNCLASSIFIED]

Hi Peter and Beth,

In order to prepare slides, I'd like to know what level of commitment you see in this activity. I could think of many things to do with our favourite toys for the validation and also for algorithm improvement, but that would probably take one Alain Protat and one Peter May full time to achieve ... What has already been discussed ?

The very basic things we can do are :

- 1) Use Darwin dual wavelength scanning (X-SACR, very similar frequencies as DPR), 2DVD, profiler, CPOL, and Berrimah data to produce calibrated reflectivities, hydrometeor classification and rain rates + attenuation characteristics + dynamics - do we commit to do analysis ourselves ? I could reproduce the 2009 CloudSat calibration work for DPR if need be. We can also go much further than that with the CPOL obs : latent heat retrievals (Q1 budget) if we implement the thermodynamic retrievals that I did at McGill. They produce latent heat profiles for TRMM so they'll probably do the same with DPR.
- 2) CP2 (is there a 2DVD there too ?) : a very good reference site for dual-wavelength and dual-pol rainfall retrievals + hydrometeor classification + attenuation characteristics. We can basically do the same as over Darwin. But how far do we want to go and what will we do that Bringi won't do ?
- 2bis) Use extensively Rainfields outputs in different locations where it runs for GPM validation (probably what Beth is thinking about ?)
- 3) Synergy with CloudSat / EarthCARE / Megha-Tropiques : again, there is a lot to do in this area. DPR (as TRMM PR) will still be short in sensitivity for low rain rates, so building rainfall properties from CloudSat (or later EarthCARE CPR) + DPR is very relevant, but I don't think we are the best people to do this, unless we invest a lot of time, and start now with TRMM / CloudSat (I have not really paid a lot of attention to the literature doing this).
- 4) Aircraft experiments : I have two very good aircraft datasets collected for the improvement of Megha-Tropiques passive microwave rainfall retrievals over land and ocean. The work done on the mass-size relationship in stratiform (and some convective cell) precipitation can be "sold" to GPM as being relevant for their algorithm improvement too. Justin Peter will start working on this. Then obviously we'll have more on the convective cores with HighWC so this should probably be the main focus of our contribution to the GPM algorithm improvement ?

Does it cover what you had discussed previously with the GPM community ? And what are they expecting from us ?

Thanks  
Alain

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**From:** Peter May  
**Sent:** Wednesday, 27 June 2012 06:43



**To:** Beth Ebert; Alain Protat  
**Subject:** GPM meeting [SEC=UNCLASSIFIED]

Dear Beth and Alain

I have to present at the GPM meeting. I can cover some of the DSD work and have a slide about the ship, but can you provide me with some slides please

Beth: validation etc

Alain: plans for Darwin and Brisbane, including synergy with Cloudsat/Earthcare/Mega Tropique and the aircraft experiments

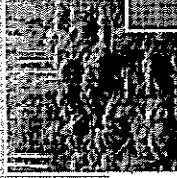
Thanks

Peter

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# Australian GV Update

[www.cawcr.gov.au](http://www.cawcr.gov.au)



Peter May (Deputy  
Director)

Beth Ebert, Alain Protat



**Australian Government**  
**Bureau of Meteorology**

The Centre for Australian Weather and Climate Research  
A partnership between CSIRO and the Bureau of Meteorology



# IPWVG validation of satellite-based rainfall

Continue Beth's work

Objectives and goals:

Pre-launch algorithm development:

- Diagnostic verification leading to improved algorithms
  - Regime-dependent error characteristics
- What blending strategies are most effective for combining data from multiple sensors?
- Can information from non-satellite sources (e.g. models, surface and upper-air observations, etc.) enhance the skill of satellite precipitation algorithms?

Post-launch evaluation:

- Ongoing monitoring of satellite precipitation accuracy
- Comprehensive error characterization
- Communication of quality information to users of precipitation data

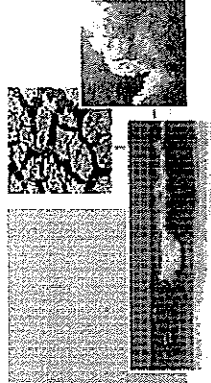


Australian Government  
Bureau of Meteorology



# IPWVG validation of satellite-based daily

## rainfall



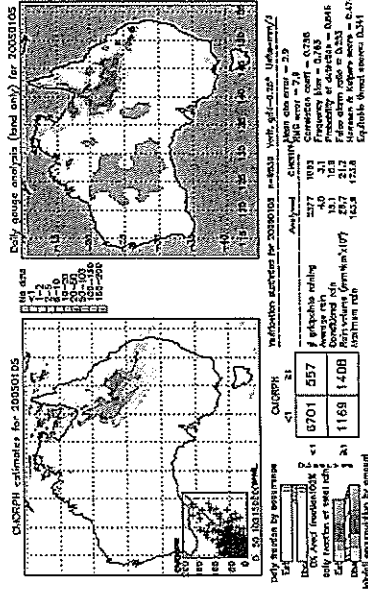
### Collaborating investigators:

#### Data providers:

- NASA Goddard Space Flight Center
- NOAA Climate Prediction Center
- NOAA Center for Satellite Applications and Research
- Naval Research Laboratory
- University of California Irvine
- Japan Aerospace Exploration Agency
- European Centre for Medium Range Forecasts
- National Centers for Environmental Prediction
- Japan Meteorological Agency
- Météo-France
- Bureau of Meteorology

#### Validation:

- Australian Bureau of Meteorology
- NOAA Climate Prediction Center
- University of Maryland
- Kyoto University



Joint with PEHRPP and WGNE

### Possible future validation partners:

- India Meteorological Department
- Korea Meteorological Administration
- NCAR (West Africa)



# IPWVG validation of satellite-based rainfall

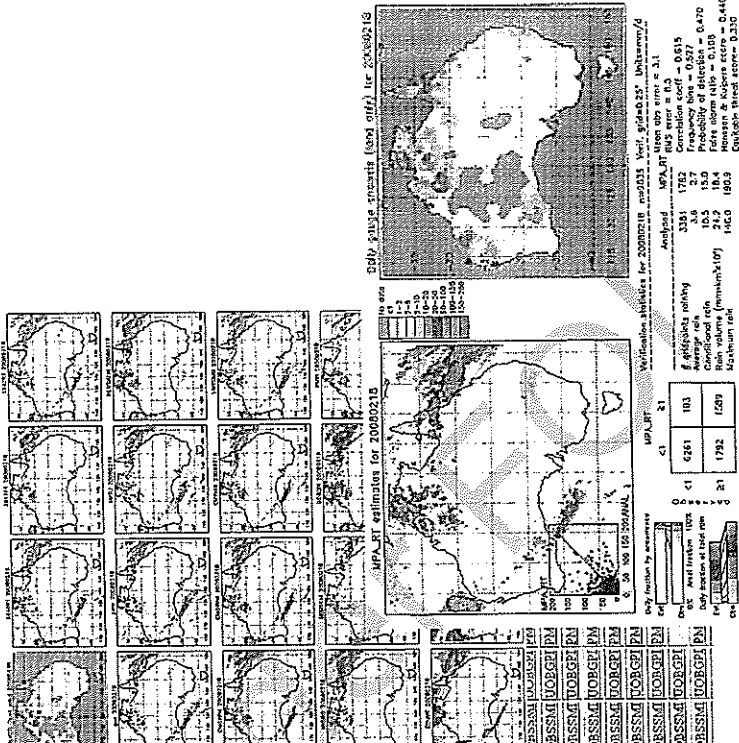
## Methodology and work plan:

- Nightly FTP of satellite precipitation estimates, verification against operational daily gauge analysis, results posted to web
- Satellite estimates archived at CICS
- Started in 2002 → long time series of statistics for product evaluation

Daily validation results for daily precipitation estimates, including semi-operational algorithms\*, resolution varies by product.

Click here to go to the CFC validation page for the US.  
Click here to go to the U. Birmingham validation page for Europe.

Valid Date (YYMM) UTC	GSPC Combined Microvays	GSPC Combined IR	GSPC Combined NRA	TRM Revised TR-Metvay	TRM Revised Metvay	TRM Revised Metvay	IR	MSR	PERSIANN	UCI	CFC Algorithms	CFC Algorithms	CFC Algorithms	TRM Revised Metvay	TRM Revised Metvay
20080225	3P40RT	3P41RT	3P42RT	3P43RT	3P44RT	3P45RT	3P46RT	3P47RT	PERSIANN	UCI	CFC	CFC	TRM	TRM	
20080226	3P40RT	3P41RT	3P42RT	3P43RT	3P44RT	3P45RT	3P46RT	3P47RT	PERSIANN	UCI	CFC	CFC	TRM	TRM	
20080227	3P40RT	3P41RT	3P42RT	3P43RT	3P44RT	3P45RT	3P46RT	3P47RT	PERSIANN	UCI	CFC	CFC	TRM	TRM	
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20080307	3P40RT	3P41RT	3P42RT	3P43RT	3P44RT	3P45RT	3P46RT	3P47RT	PERSIANN	UCI	CFC	CFC	TRM	TRM	
20080308	3P40RT	3P41RT	3P42RT	3P43RT	3P44RT	3P45RT	3P46RT	3P47RT	PERSIANN	UCI	CFC	CFC	TRM	TRM	
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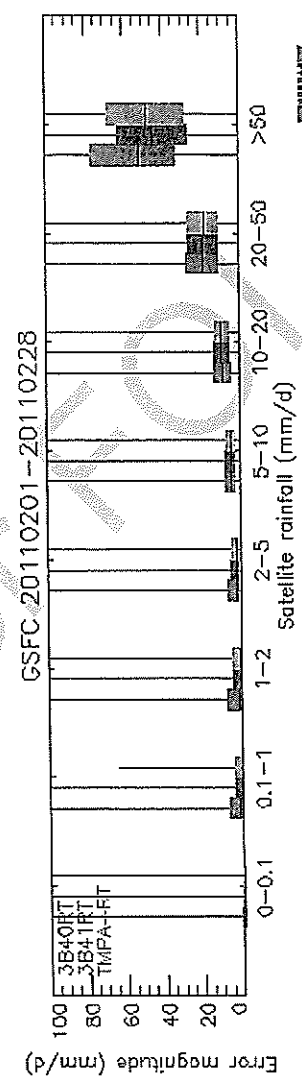
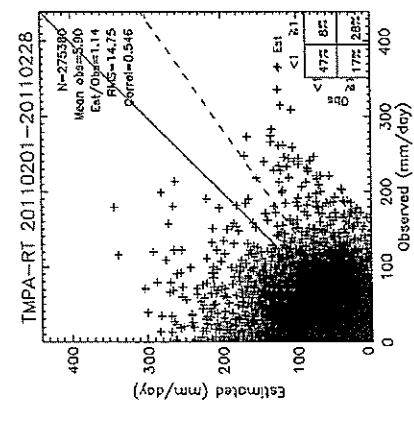
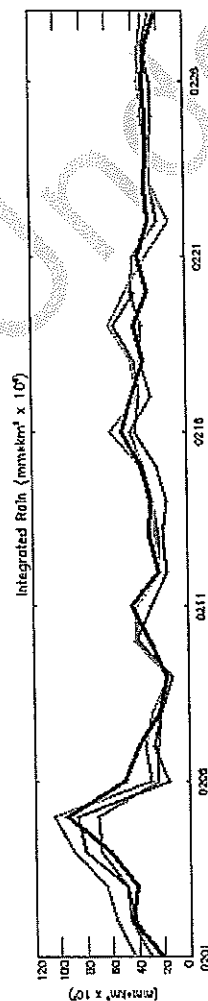
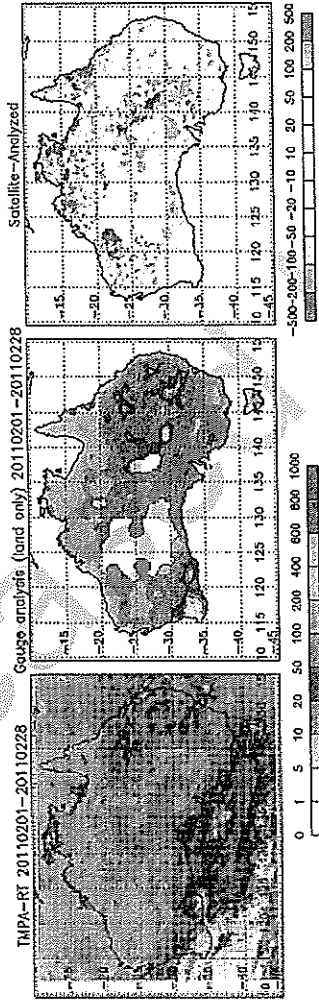


# IPWVG validation of satellite-based rainfall

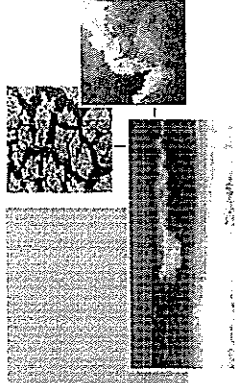
- Monthly and seasonal diagnostic validation summaries

Comparative statistics for 20110201-20110228

	3B4-RT	3B4-IRT	TMPA-RT
<b>OBSERVED</b>			
Rain Area ( $\text{km}^2 \times 10^3$ )	2804	2804	2804
Avg Intensity ( $\text{mm/d}$ )	12.99	12.99	12.99
Rain Volume ( $\text{mm} \times \text{km}^2 \times 10^6$ )	36.41	36.41	36.41
Max Intensity ( $\text{mm/d}$ )	149.90	149.90	149.90
<b>ESTIMATED</b>			
Rain Area ( $\text{km}^2 \times 10^3$ )	1579	2072	2177
Avg Intensity ( $\text{mm/d}$ )	21.27	15.91	18.84
Rain Volume ( $\text{mm} \times \text{km}^2 \times 10^6$ )	33.58	32.87	41.02
Max Intensity ( $\text{mm/d}$ )	291.09	143.95	212.98
<b># Gridpoints</b>			
Mean Abs Error ( $\text{mm/d}$ )	9835	9835	9835
RMS Error ( $\text{mm/d}$ )	6.25	5.69	6.15
Avg. Correlation Coeff.	16.21	13.26	14.61
Bias Score	0.459	0.537	0.340
Probability of Detection	0.563	0.738	0.777
False Alarm Ratio	0.482	0.584	0.625
Critien Success Index	0.145	0.208	0.196
Honssen & Kuipers Score	0.445	0.506	0.542
Equitable Threat Score	0.411	0.451	0.494
	0.289	0.298	0.335



# IPWVG validation of satellite-based rainfall



## Plans

Continue regional daily rainfall validation

Verify hourly and 3-hourly satellite precip estimates using neighborhood verification methods

## Resources:

### Personnel:

Bureau of Meteorology – 1 part-time

Other partners – similar

### Computing / IT:

Satellite precipitation archive at CICS (U. Maryland)

IPWVG validation web sites

Home page at Bureau of Meteorology

Regional validation web pages at participating centers

### Auxiliary data:

Operational daily rain gauge analysis

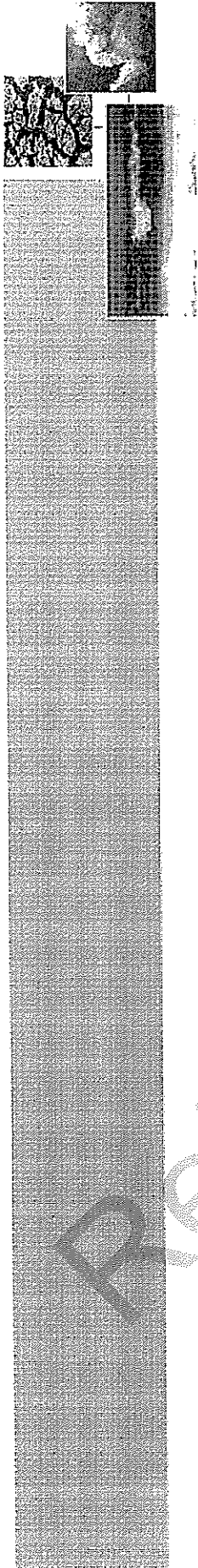
Rainfields hourly merged radar gauge analysis



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Released Under FOI



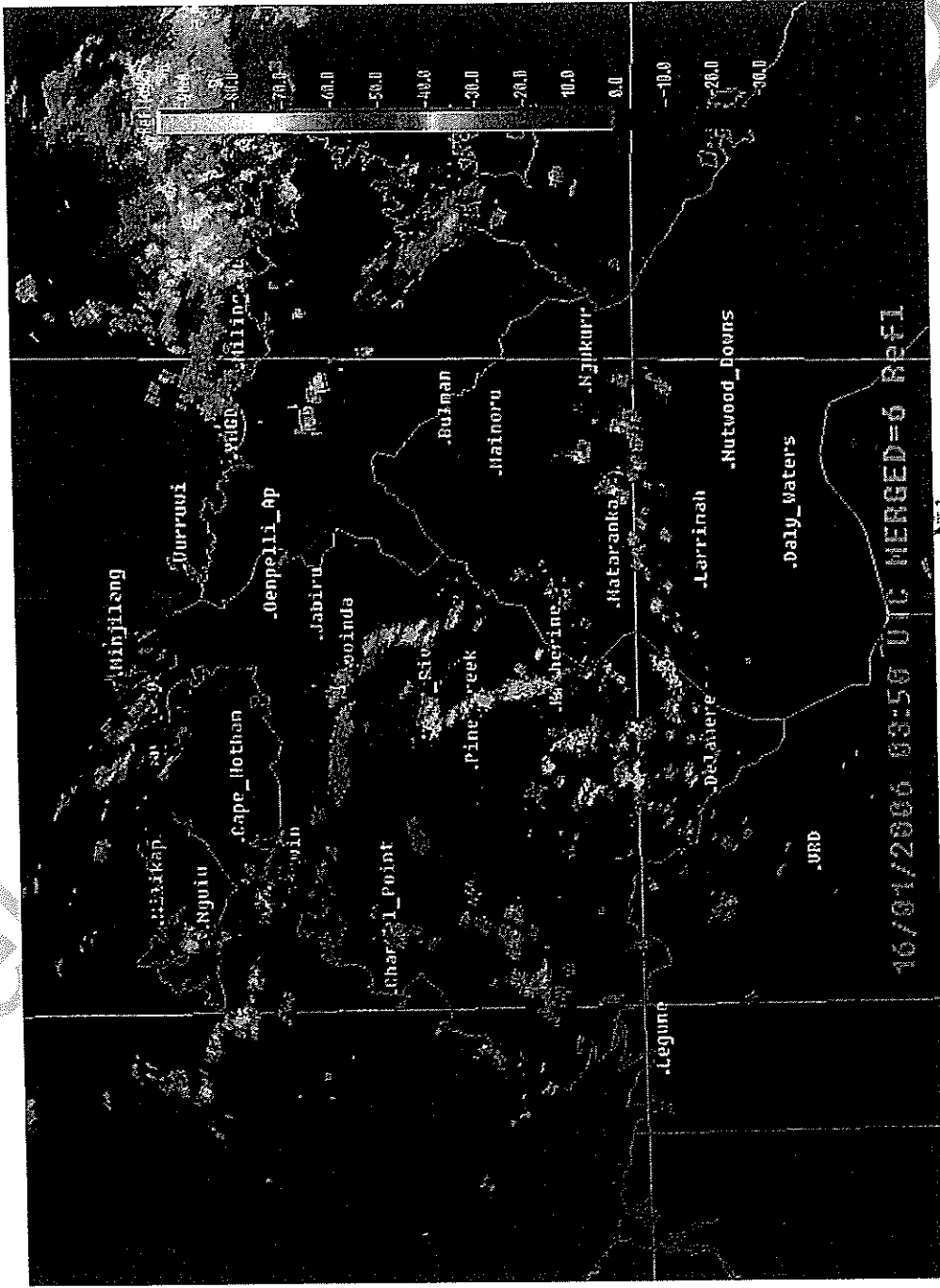
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Bureau of Meteorology

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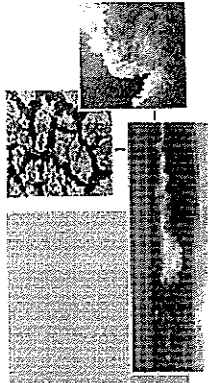




What is special about the environment that controls this?

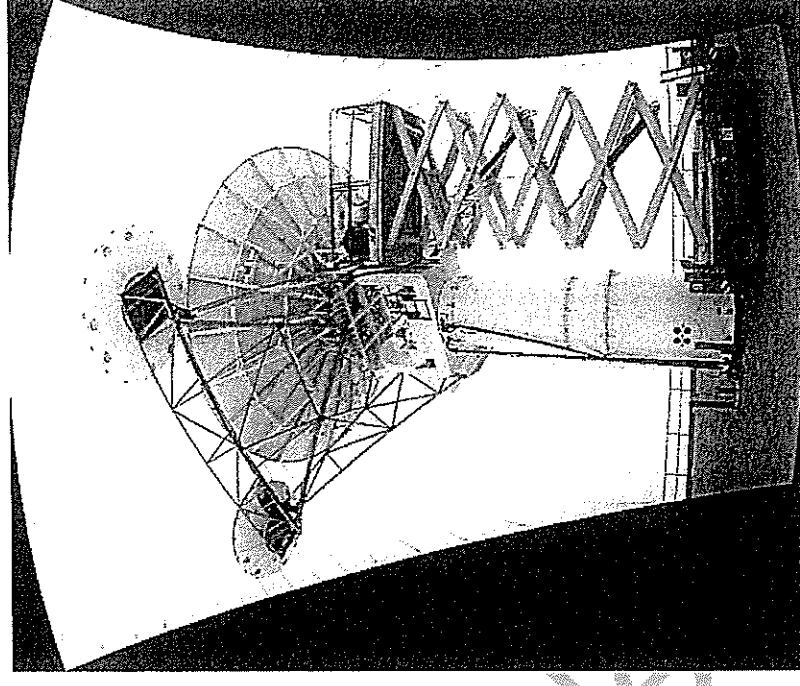


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## Queensland – CP2 Subtropical site

- CP2 radar
- Dual frequency (S, X), dual pol.
- Recent upgrade of antenna
- Under repair – should be operating later this year
- Include 2DVD, rain gauge network
- Samples severe storms including large hail
- Dual Doppler with operational network
- Collaborating with Bringi and Thurai



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# Plans for CP2 use for GPM GV

Produce high-quality radar estimates from the S-band + X-band observations

New approach for hydrometeor classification

Rainfall DSD parameters (dual-wavelength + dual-pol + 2DVD)

Convective vs stratiform rainfall comparisons

3D dynamics from CP2 + surrounding operational radars

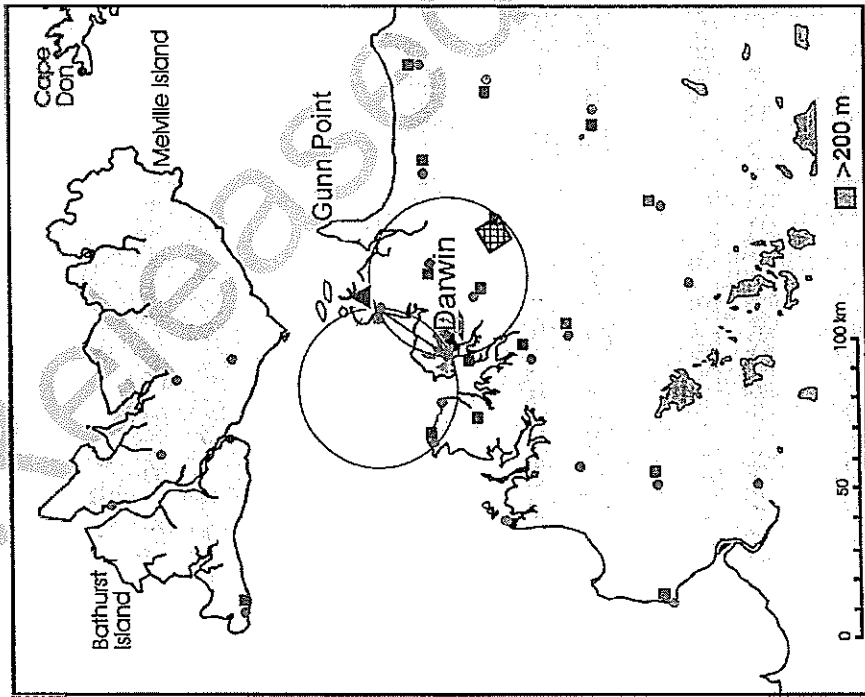
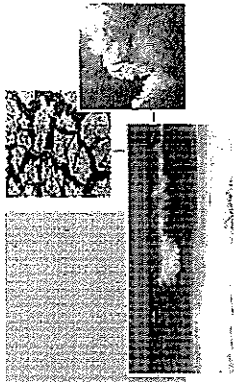
Study the regime dependence of the rainfall parameters to provide valuable inputs to GPM algorithms

Crystal density – size relationships can be constrained with dual -  $\lambda$   
A crucial assumption in land-based passive microwave rainfall techniques

Regime variability of DSD parameters (Nw, Do)



# Background - The DCRS/CSIRO/ARM sites



- Polarimetric radar (5cm)**
- Doppler weather radar Profiler (50 and 920 MHz)**
- AVHRR, MTSAT**
- LW, SW Radiation**
- Soundings**
- Cimel**
- Aerosol, GHG measurements in 2010**
- ARM operational:**
- MMCR (Doppler 35 GHz Cloud Radar) MPL (Lidar)**
- Lidar Ceilometer**
- AERI**
- MWR (Microwave Radiometer)**
- WSI**
- Surface Met**
- SkyRad: PSP/PIR UVB Global PSP MFRSR IRT**

**Darwin Climate Monitoring Research Station**

- Doppler (C-Band) Radar
- Polarised Profiler (50 / 920 MHz)
- Rawinsonde
- C-Scale Rain gauge
- D-Scale, M-Scale Rain gauge
- Automatic Weather Station

**Darwin Atmospheric Radiation and Cloud Station**

- Solar Terrestrial Radiation
- Surface Meteorological Instruments
- Micro-Pulse Lidar
- Millimeter Cloud Radar
- Ceilometer
- Whole Sky Images
- Atmospheric Emiler
- Radiance Interferometer

**and now a dual frequency scanning cloud radar, Raman lidar, IR Doppler lidar, aerosol labs,**



# Plans for Darwin CRS use for GPM GV

New instrument at the Darwin CRS station :

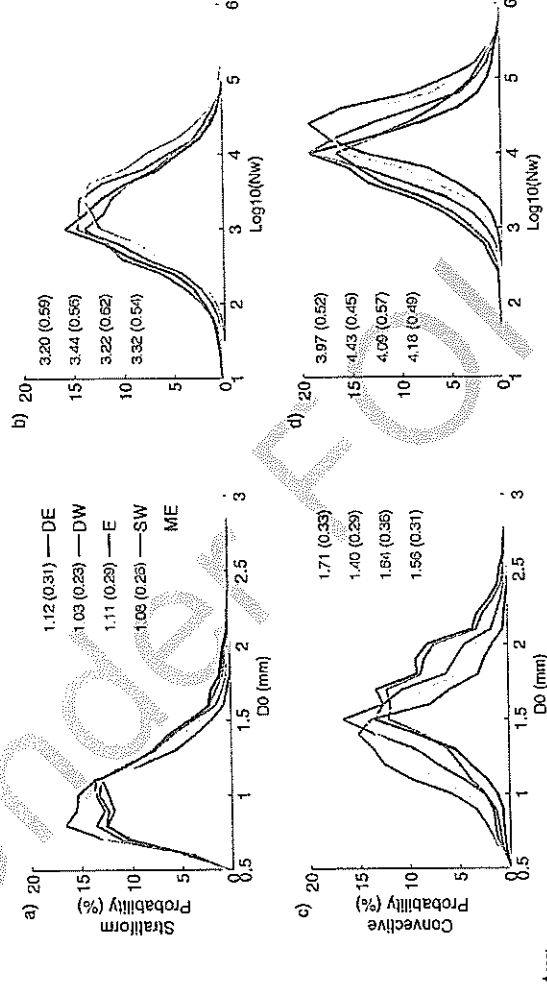
- The Scanning ARM Cloud Radar (SACR) : 10 and 35 GHz, and scanning !
  - Almost a ground-based simulator of GPM DPR + much better sensitivity

Comparison with Darwin CPOL and dual-frequency profilers rainfall rates will be a nice test-bed for GPM algorithm validation

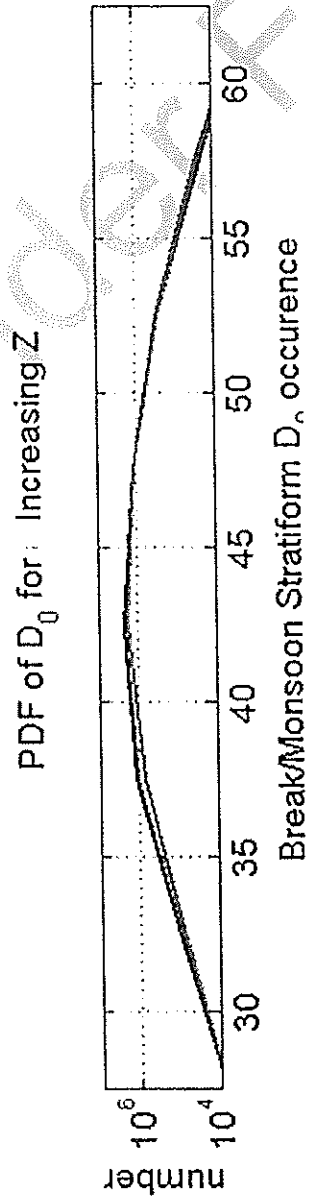
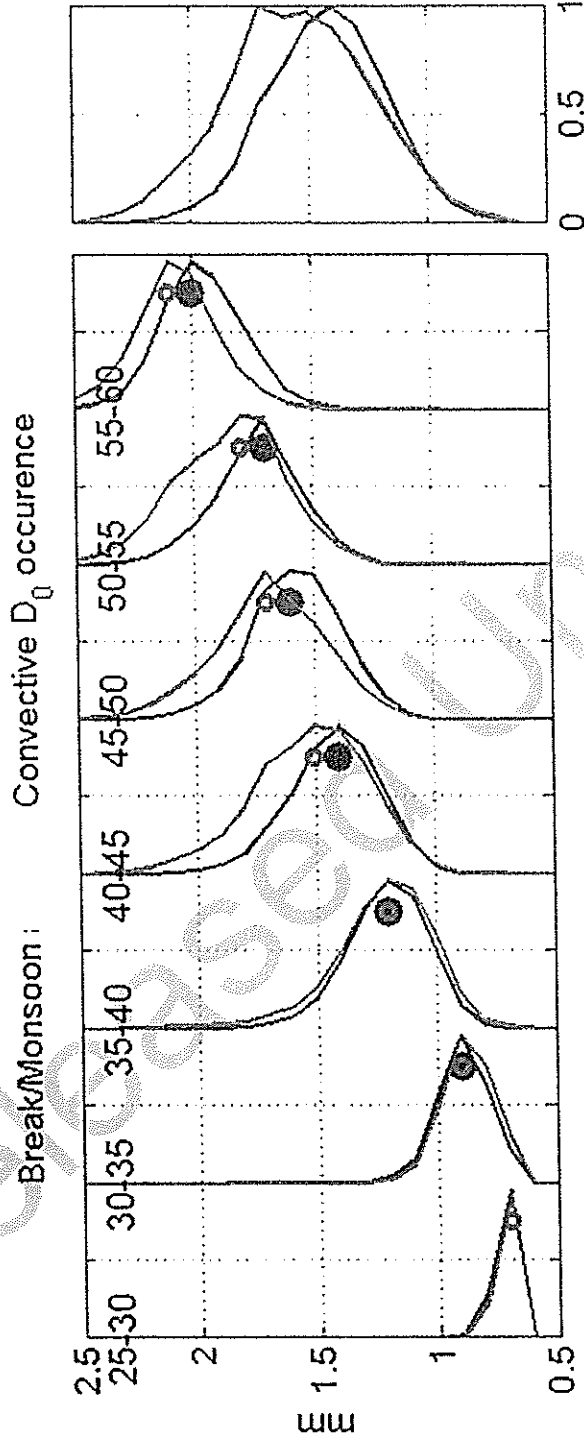
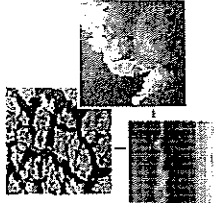
CPOL + Berrimah : 3D wind + thermodynamic perturbations (e.g., Protat and Zawadzki 1999, 2000) → Q1 budget and latent heating profiles

Regime dependence of convection parameters is being studied :

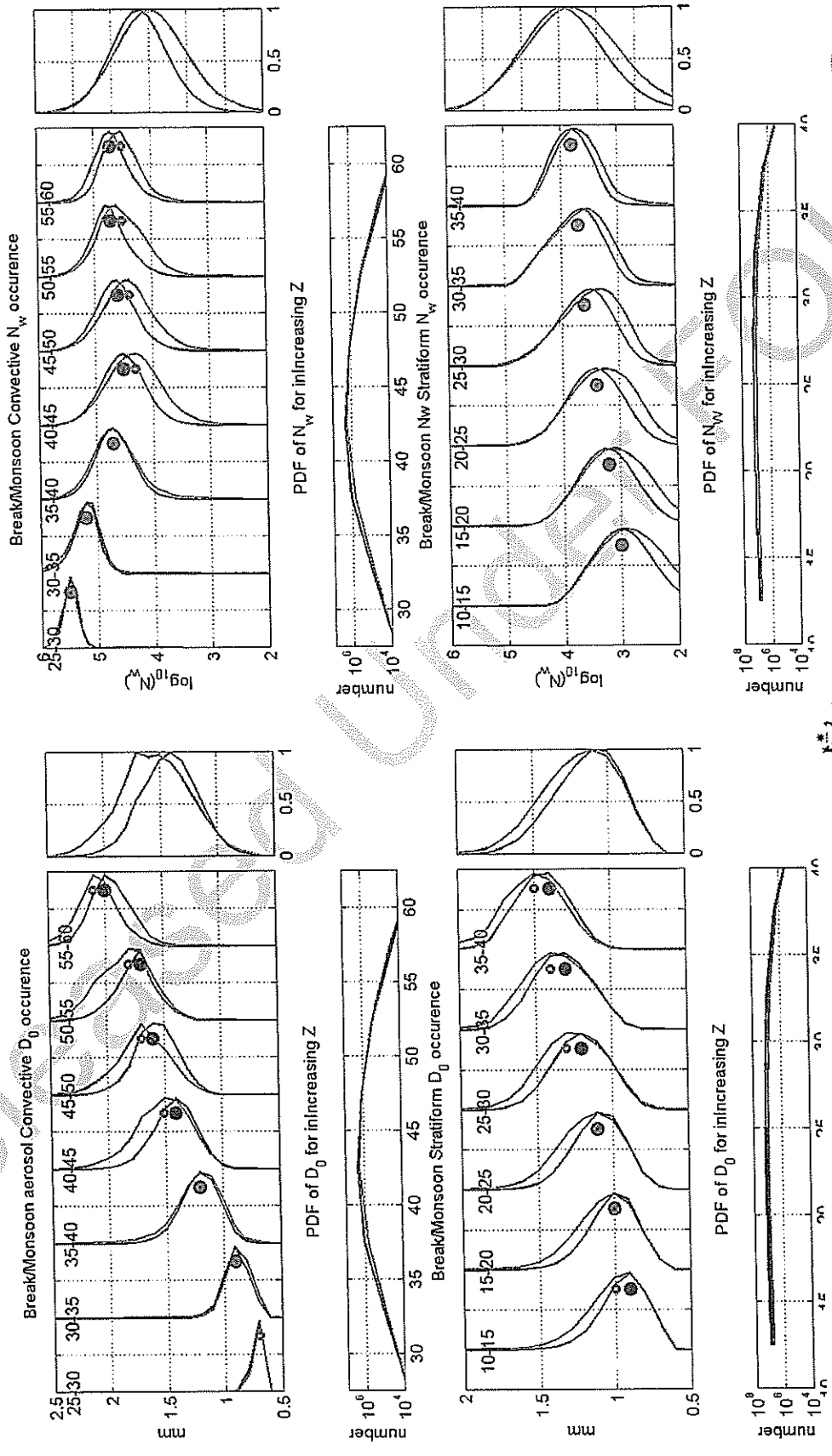
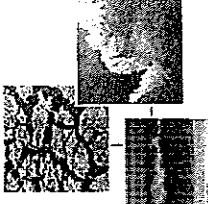
- Nw, Do (Penide 2012)
- Convective cloud tops (Kumar 2012)
- Ice microphysics (Protat 2011)
- Diurnal cycle (May 2012)
- Aerosol effect on precip (May 2010)



Example of PDF's of DSD's (Red: break, Blue: monsoon) from polarimetric estimation



# Example of PDF's of DSD's (Red: break, Blue: monsoon) from polarimetric estimation



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Some Opportunities

Darwin tropical site: incl new instruments

New Australian RV Investigator

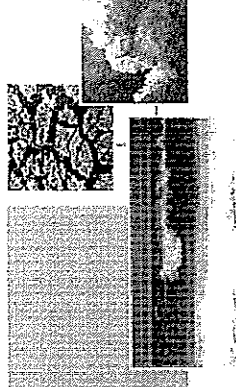
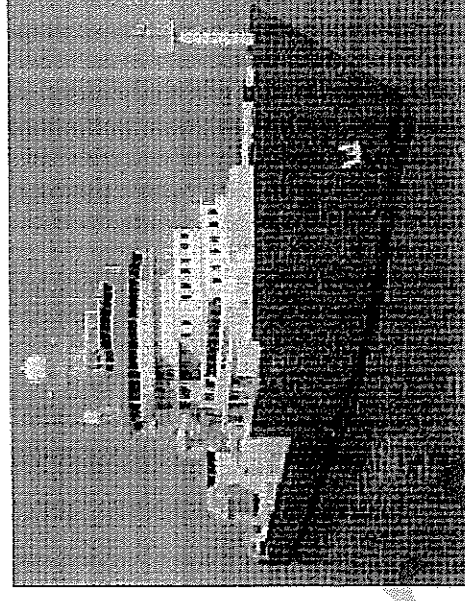
Substantial atmospheric capability

Dual Pol Wx Radar

Aerosol and gas lab

Lidar etc

**First Wx radar cruise in Sept 2013 over  
the Southern Ocean**



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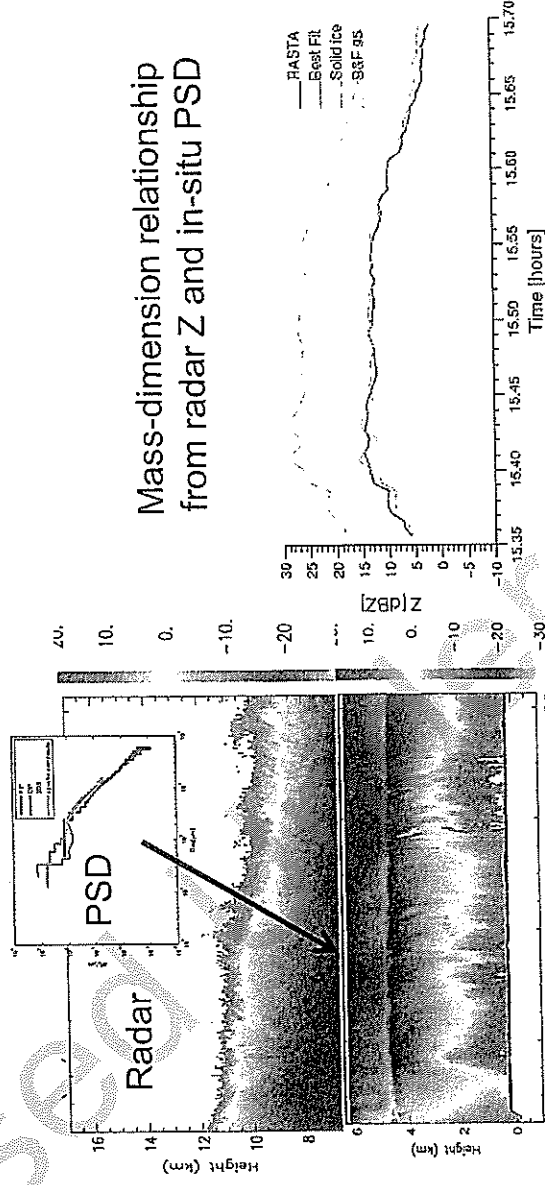
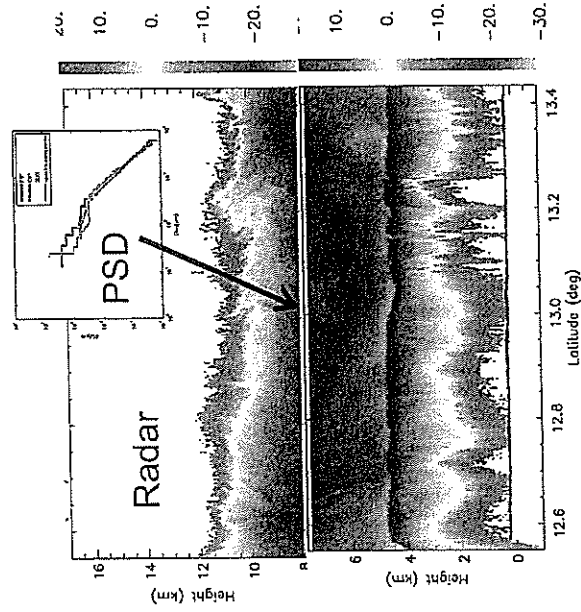
CSIRO



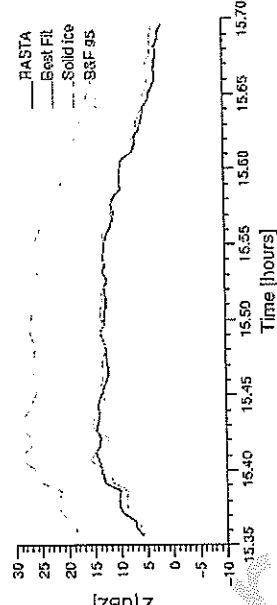
## More Opportunities

### Recent aircraft experiments :

MT-AFRICA (2010), DYNAMO (2011) : Validation of Megha-Tropiques rainfall algorithms  
Provides collocated in-situ and airborne Doppler radar observations to better constrain the crystal mass-size relationship, crucial for GPM passive rainfall retrieval over land

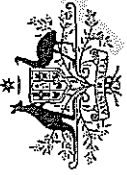


Mass-dimension relationship  
from radar Z and in-situ PSD



### Upcoming aircraft experiments :

The HighWC Study (Darwin, 2014) : Penetration of oceanic deep convective cores with state-of-the-art in-situ probes + airborne Doppler radar – validation of ground-based products to be used for GPM validation



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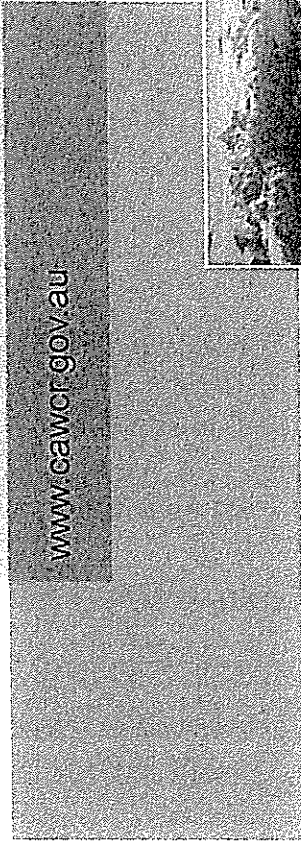


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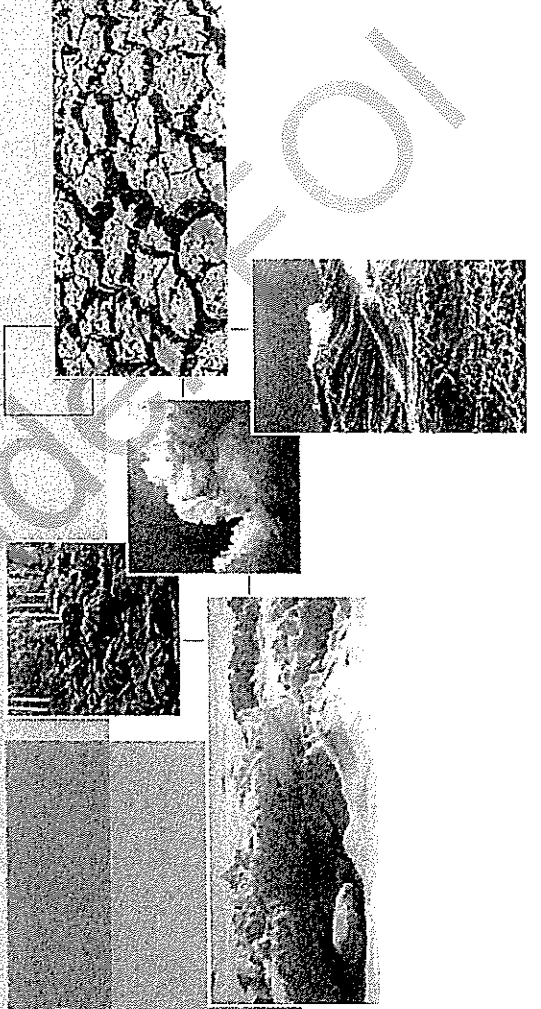
**Peter May**  
**CAWCR Deputy Director**

**Phone:** [Redacted]  
**Email:** [Redacted]

**Web:** [www.cawcr.gov.au](http://www.cawcr.gov.au)



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Thank you!