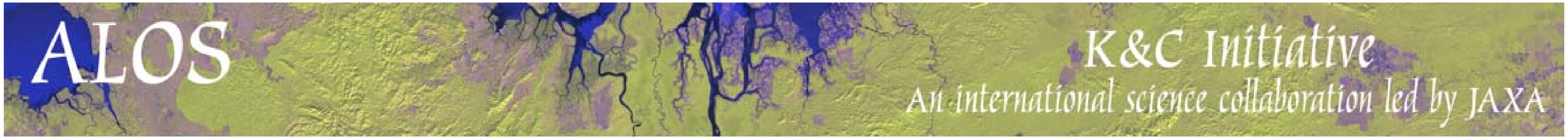


# K&C Science Report – Phase 2

# Investigating the use of PALSAR for wetland assessment in semi-arid environments of Australia: The Murray-Darling Basin (MDB)

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Science Team meeting #15
JAXA TKSC/RESTEC HQ, Tsukuba/Tokyo, January 24-28, 2011

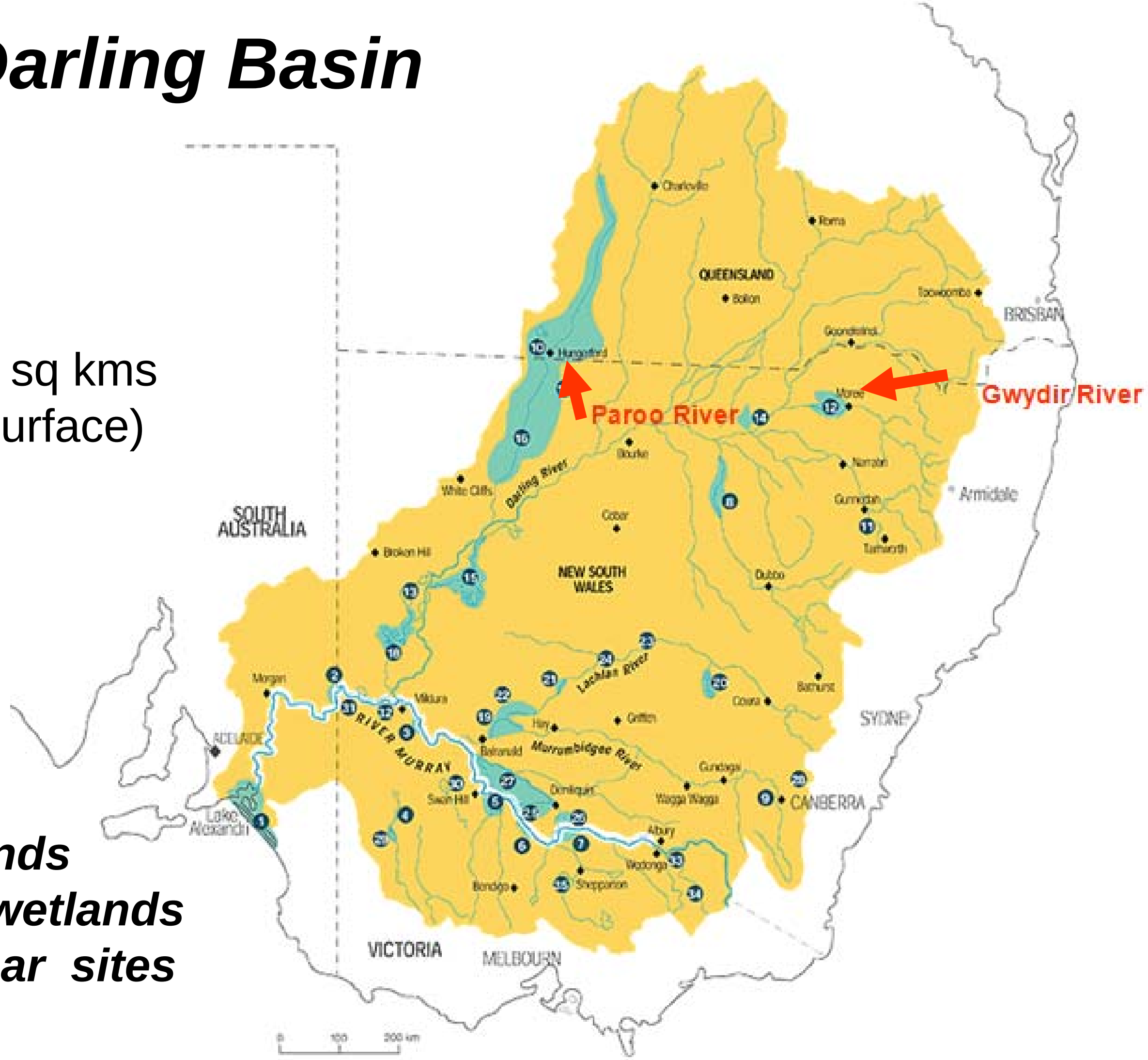
## Phase 1 Report

# *Wetland monitoring of flood-extent, inundation patterns and vegetation, Mekong River Basin, Southeast Asia, and Murray-Darling Basin, Australia*

Milne, A.K., Tapley, I. , Mitchell, A.L., and Powell, M.J. ***Trial of L-band radar for mapping inundation patterns in the Macquarie Marshes,*** Volumes I, II and III, Consultancy Report Prepared for the NSW Department of Environment and Climate Change (DECC), Sydney, December, 2009, pp280

# *Murray-Darling Basin*

Area 1.1 million sq kms
(1/7 Aust land surface)




***Over 200 wetlands***
***35 significant wetlands***
***10 listed Ramsar sites***

# *Major Objectives*

- **Use PALSAR  for mapping and monitoring wetlands in the MDB arid zone**
- **Analyse pattern of flood flows, duration and recession of surface water**
- **Assess vegetation, soil and animal response to periodic flooding**
- **Investigate the effect of environmental flows in semi-arid  landscapes**

# *Extension Phase Proposal*

## *Deliverables*

- **Methods for detecting and characterisation vegetation, soil and water class in semi-arid wetland environments**

- **Development of an operational system using PALSAR data for monitoring wetlands and assessing the effect of environmental flows on vegetation and soil response in semi-arid wetland environments.**

- **Evaluation of Scansar efficiency in detecting and mapping the regional distribution of semi-arid wetland distribution in the MDB.**

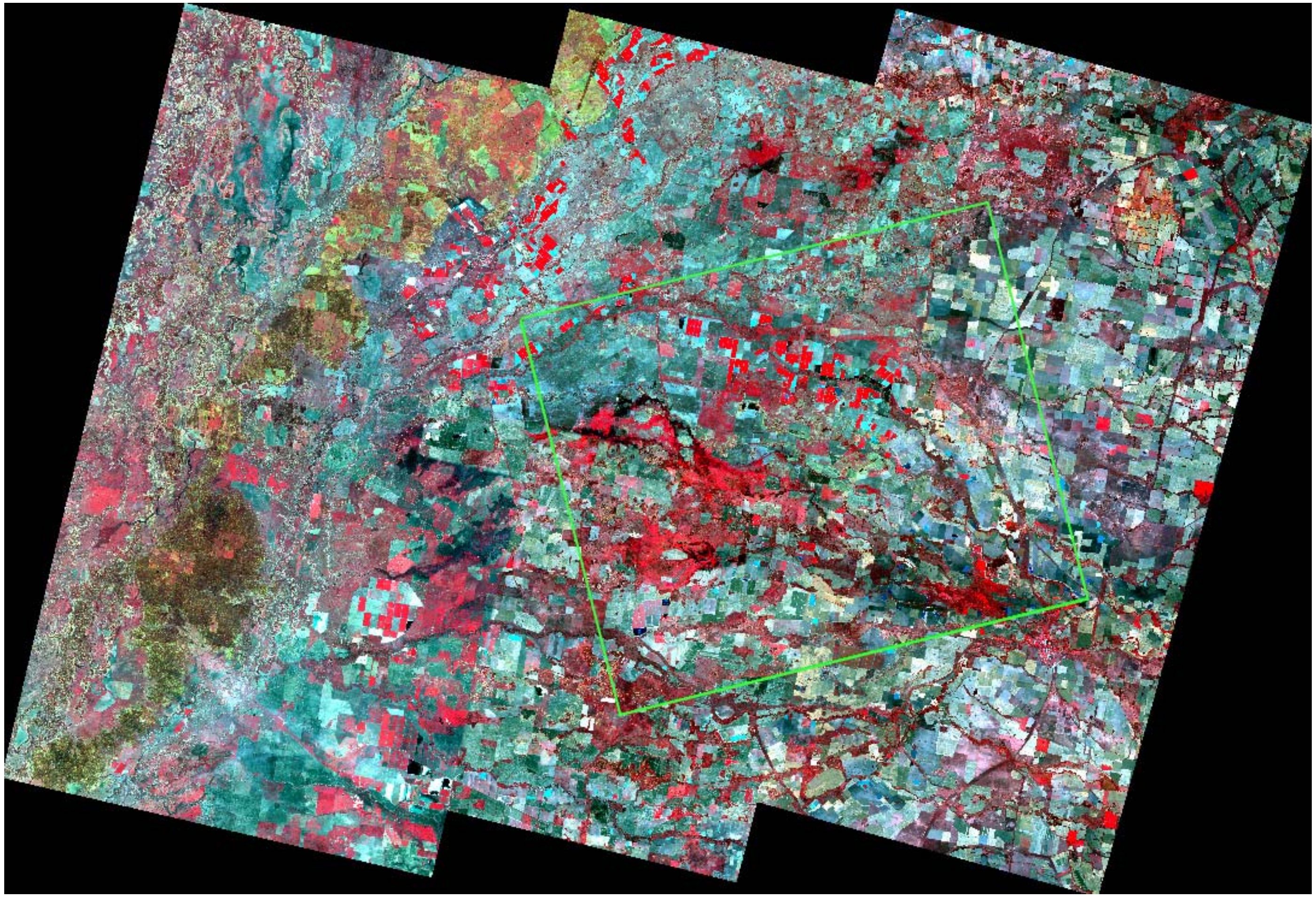
# *Gwydir Wetlands*

- **The Gwydir Wetlands are located in the Gwydir valley which lies to the north of the Macquarie Marshes, the site of the previous study.**

- **The wetlands include the Lower Gwydir and Gingham watercourses, both of which end in terminal floodplains, except during major floods when water may reach the nearby Barwon River.**

- **The Gwydir Wetlands support an estimated area of 102,000 ha of wetland vegetation and are recognized internationally for their significance as waterbird habitat and are listed in the Ramsar Convention.**

- **The wetlands and wider area also support significant grazing and irrigated agriculture industries.**

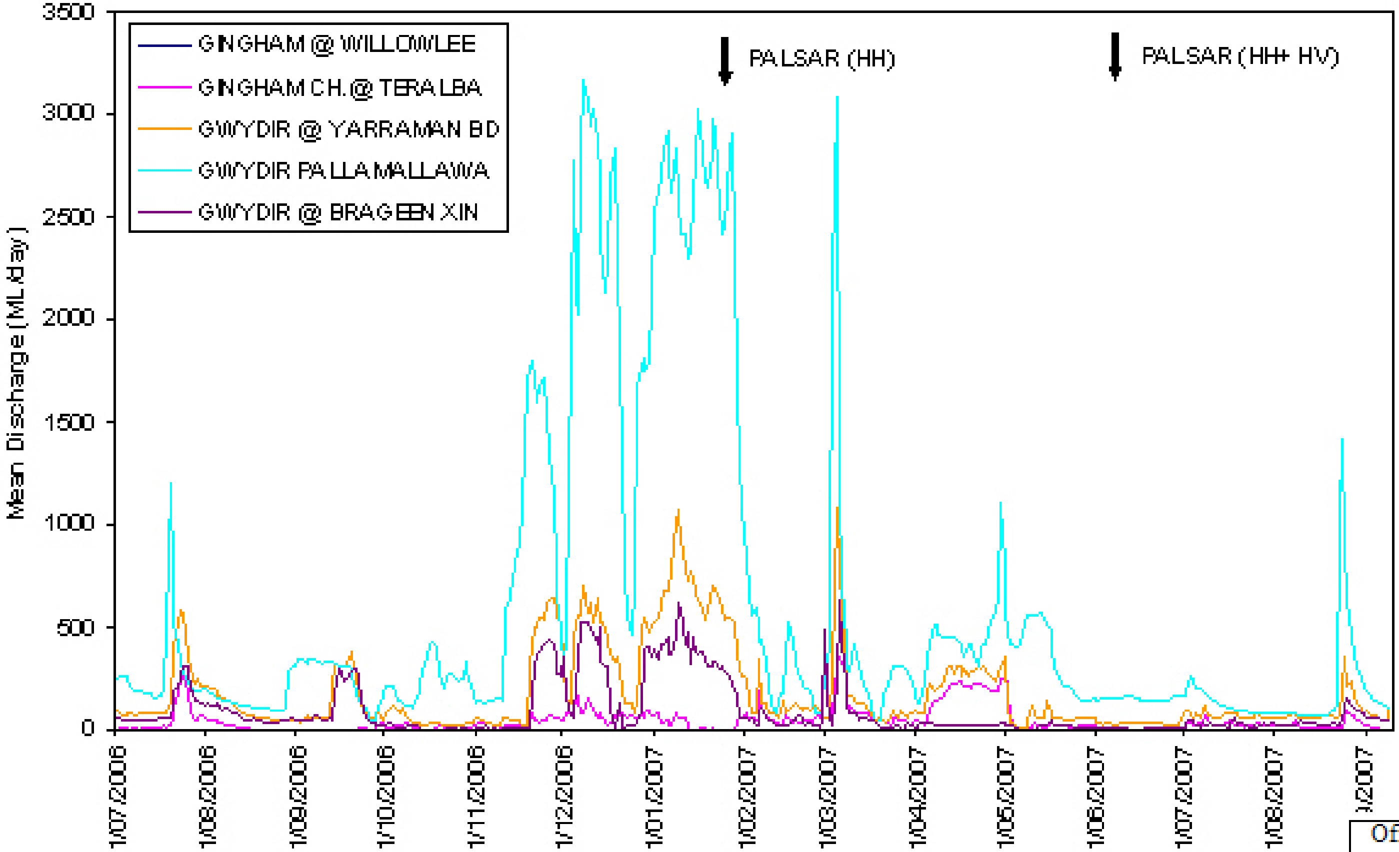


***SPOT-5 mosaic of the Gwydir wetlands with the extent of ALOS PALSAR coverage overlain (green outline).***

***ALOS PALSAR data for the Gwydir Marshes acquired on 12/6/2007: HV polarisation***

# Inundation Mapping

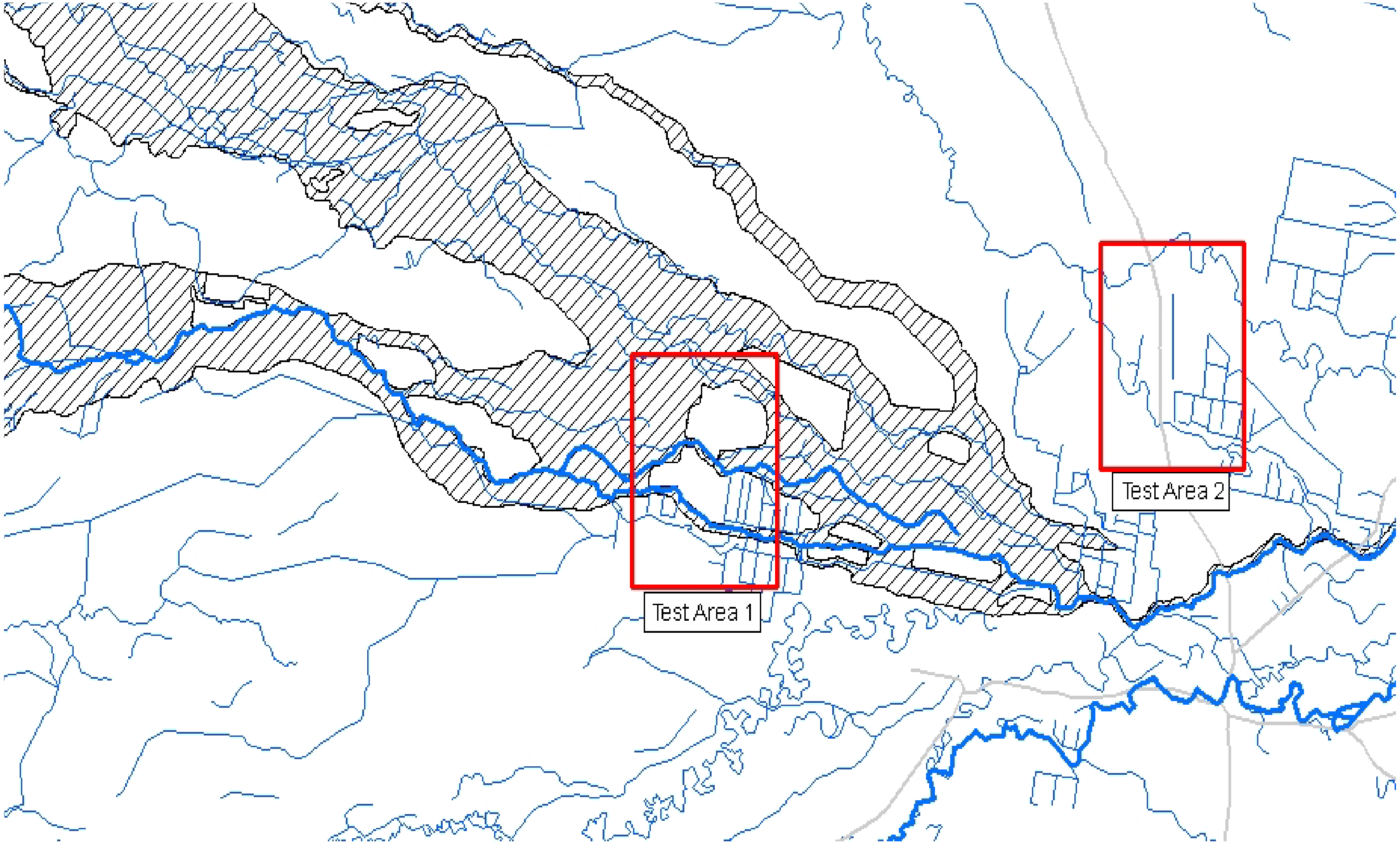
***Daily river discharge (mean ML/day) for the Gwydir Wetlands as recorded at five gauging stations between January 2006 and September 2007.***




**Acquisition dates of PALSAR imagery shown by arrows.**

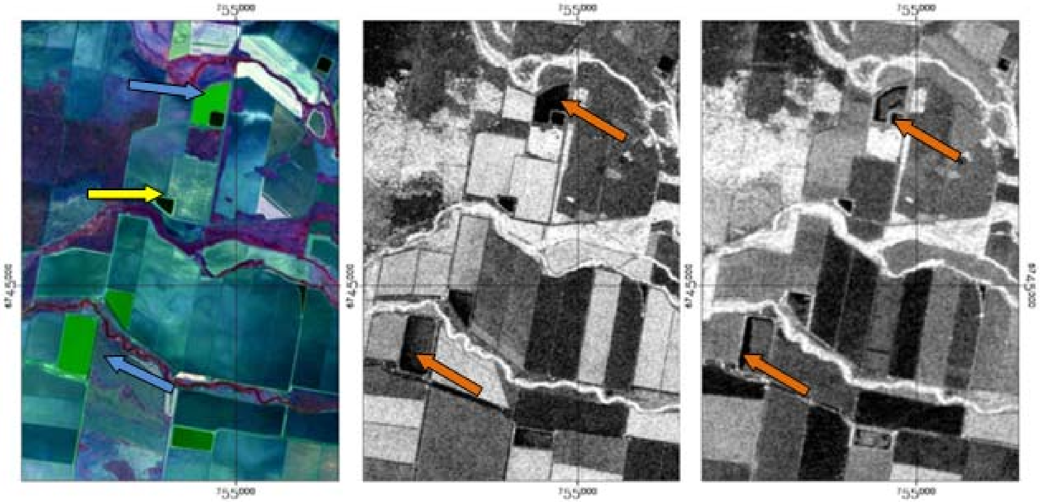
**TABLE I.**
**ALOS PALSAR coverage of the Gwydir wetlands.**

| Off-nadir angle (°) | Path no. | Row no. | Image date |
|---|---|---|---|
| 34.3 | 369 | 6590 | 25/1/2007 FBS |
| | 369 | 6590 | 12/6/2007 FBD |



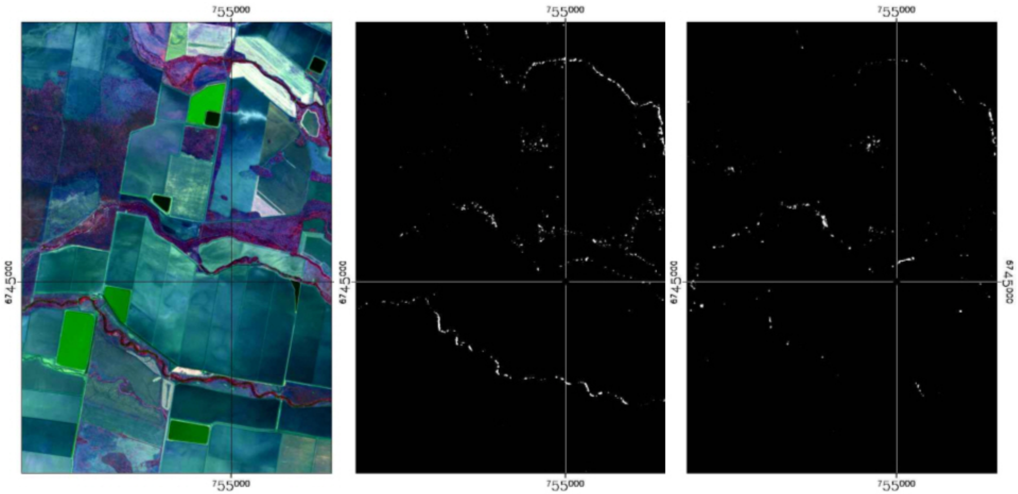

***Location of Gwydir Wetlands Test Areas #1 and #2. Hatched areas indicate areas inundated at time of aerial photo acquisition (26 August 2005 – 10 October 2005).***

# Inundation Mapping



SPOT 3:1:4 (RGB) PALSAR Jan 2007 PALSAR June2007

***Gwydir wetlands Test Area #1: identification of open dams (dark albedo – yellow arrow) and irrigated paddocks (green tones - blue arrow) in SPOT-5 (bands 3:1:4 displayed as R,G,B respectively) and PALSAR HH-polarisation water in paddock data for January and June 2007. Changing water levels in dams and irrigation paddocks was black, specular surfaces in radar images (orange arrows).***

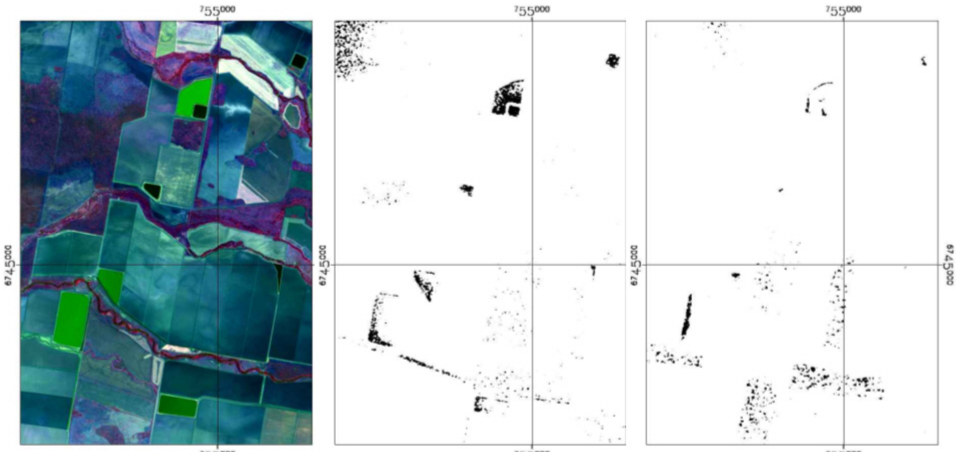


SPOT 3:1:4 (RGB) PALSAR Jan 2007 PALSAR June2007

***Gwydir wetlands Test Area #1: contrast enhancement of PALSAR images highlight rough, dielectric surfaces, and water-beneath-canopy targets (i.e., bright response).***

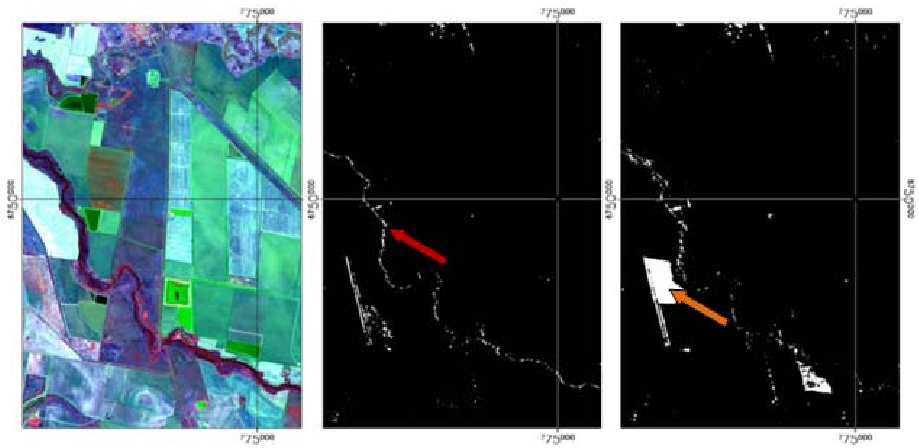
***White areas on the masked PALSAR images correspond to areas of inundated trees and shrubs.***

# *Inundation Mapping*



SPOT 3:1:4 (RGB) | PALSAR Jan 2007 | PALSAR June2007

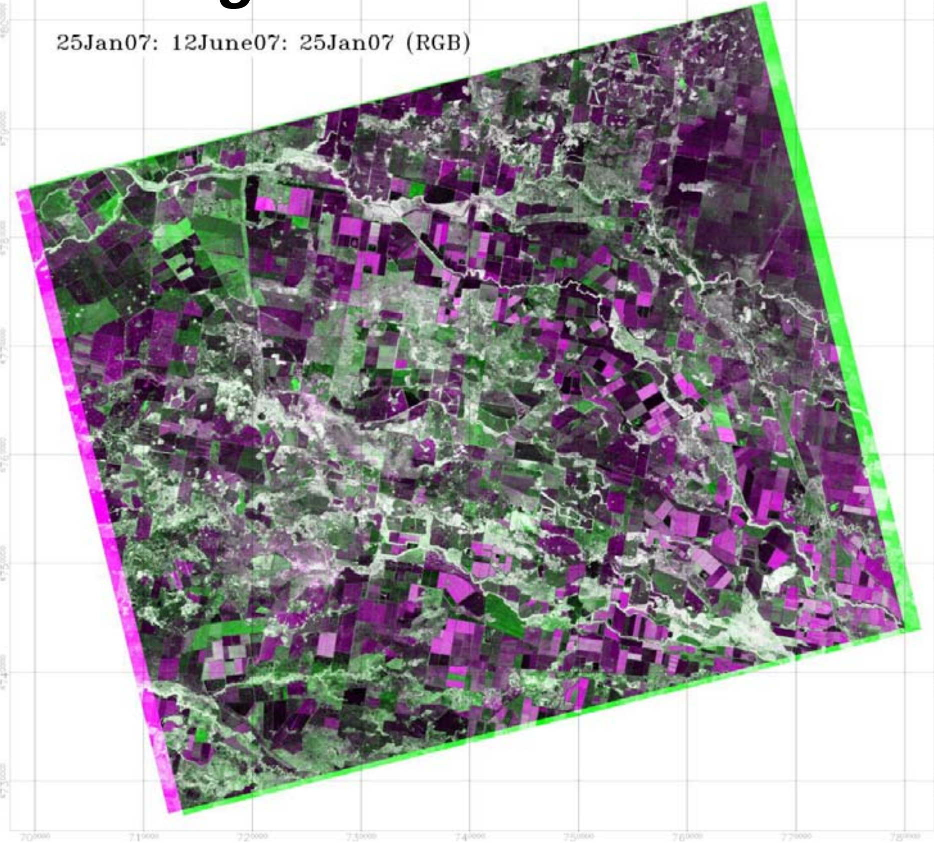
***Gwydir wetlands Test Area #1: contrast stretching of PALSAR imagery to highlight areas of open water and/or ground features with smooth, specular surfaces resulting in zero backscatter to the radar sensor. These areas are shown in black on the derived masks.***

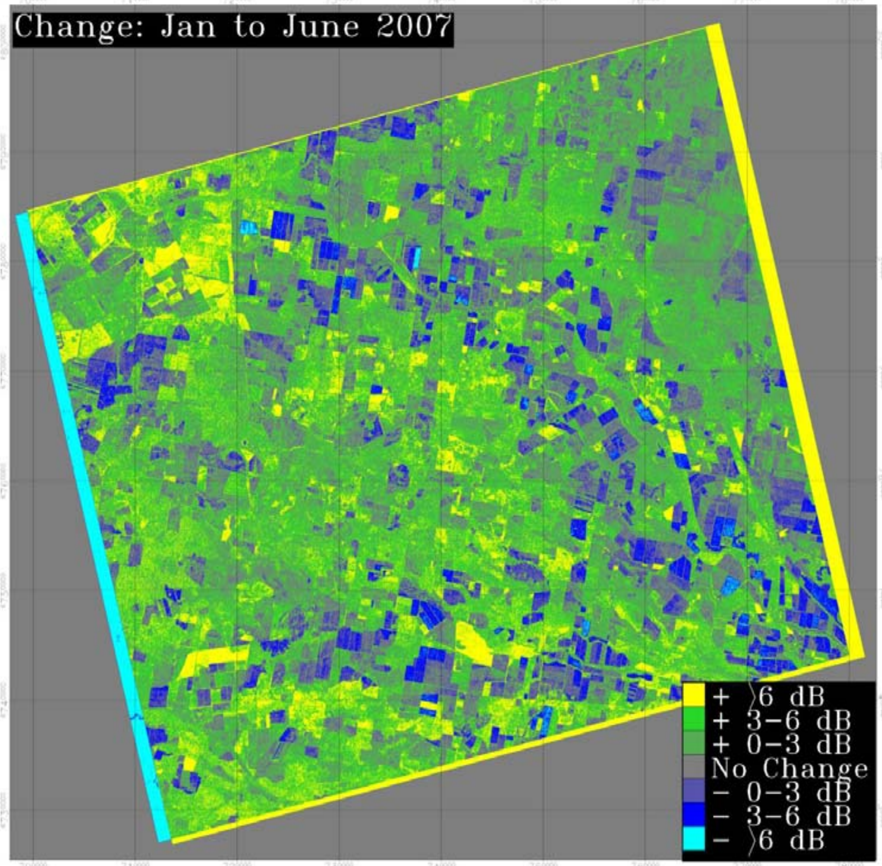


SPOT 3:1:4 (RGB) | PALSAR Jan 2007 | PALSAR June2007

***Gwydir wetlands Test Area #2: contrast enhancement of PALSAR images to highlight rough, high dielectric surfaces, and water-beneath-canopy targets (red arrow). These areas appear white on the derived masks. There is a large area of high soil moisture (bright response) in the masked PALSAR image from June 2007 (orange).***

# Change Detection



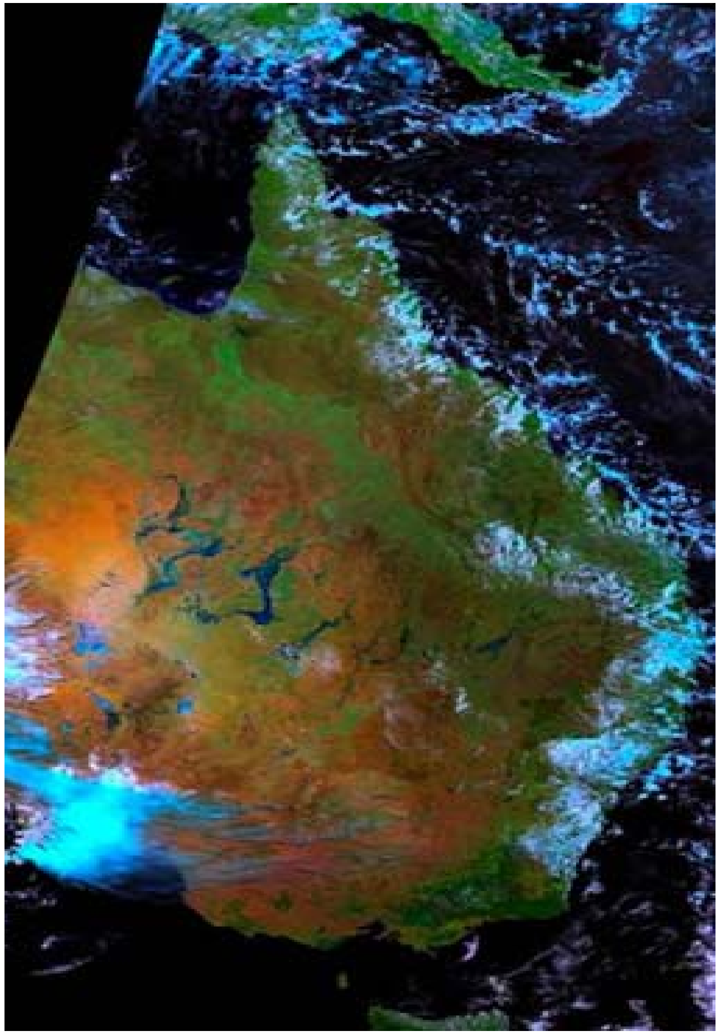

***Left** - PALSAR 3-band colour composite for the Gwydir wetlands: Jan 2007: June 2007:Jan 2007. The purple areas are dominated by the January (summer) response while the green areas are dominated by the June (winter) response.*

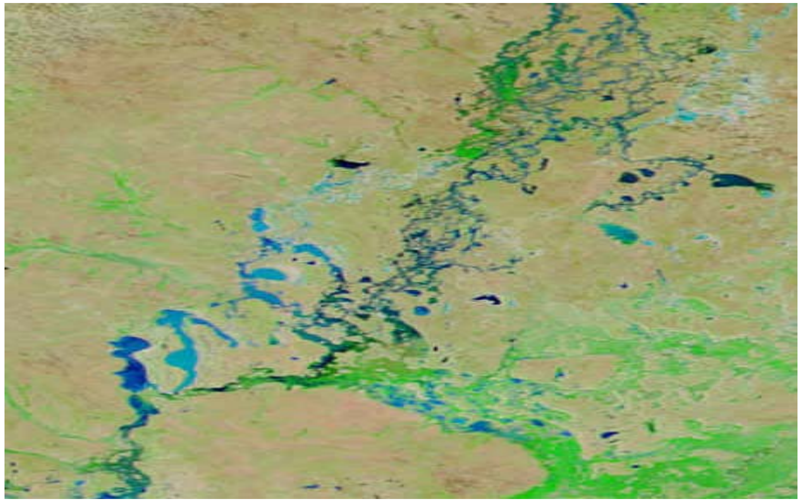
***Right** - Change detection between January and June 2007. A decrease in backscatter is observed over most of the agricultural areas (of the order of 0.1 – 6 dB), while areas with higher backscatter are dominated by wetlands and grassland.*

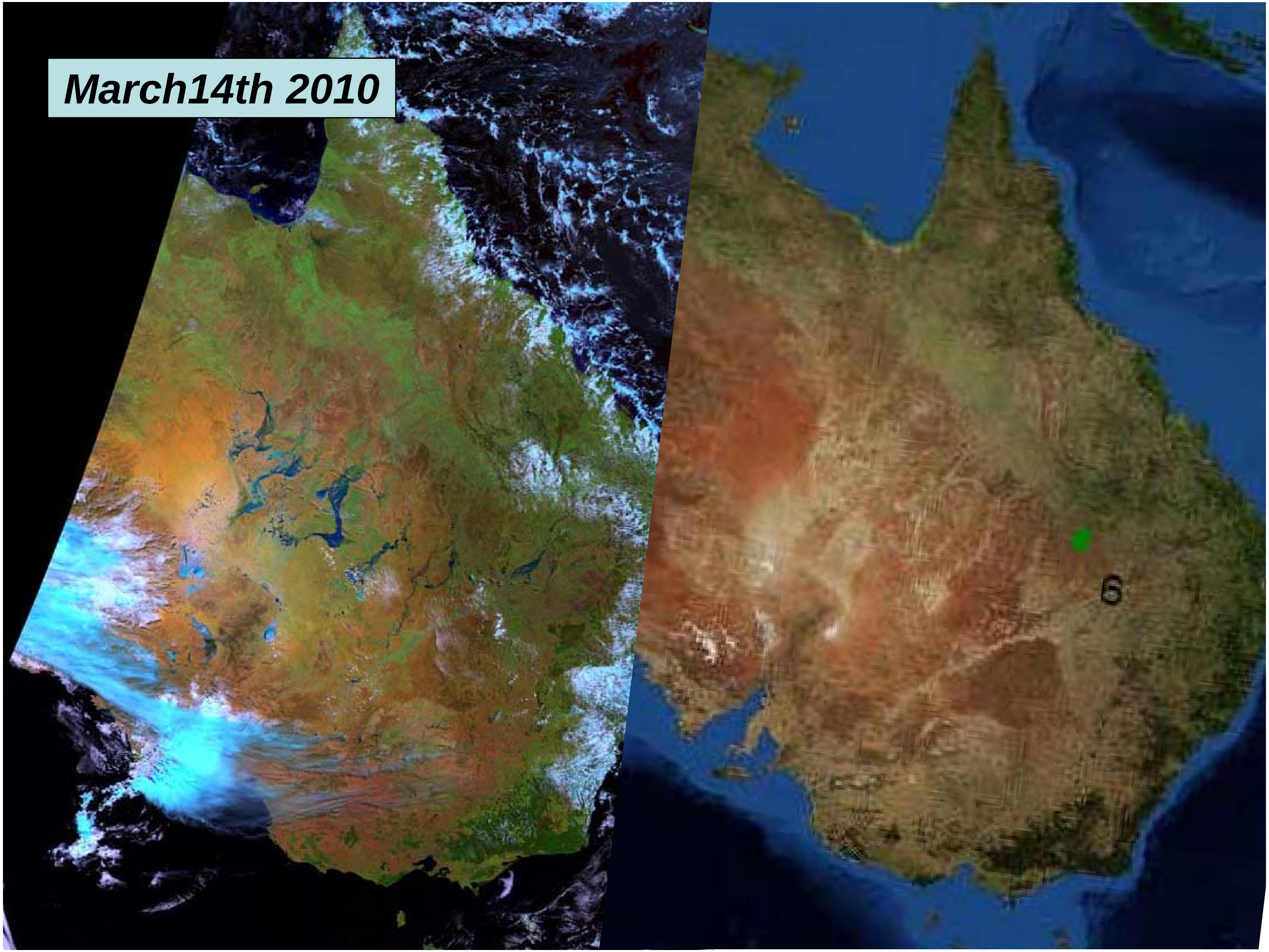
# *Paroo River Wetlands*

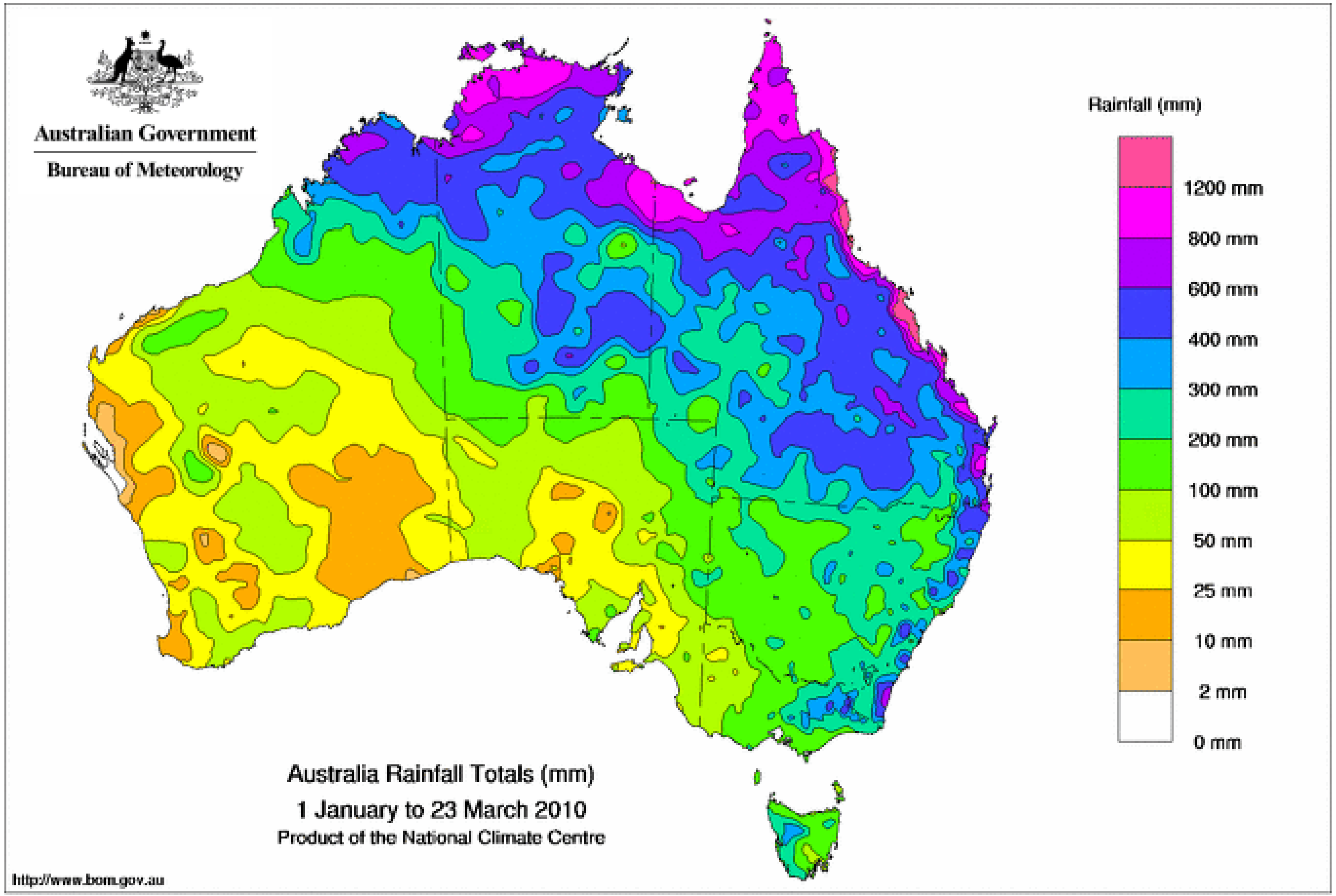
- **The Paroo and Warrego catchments cover 7,400,224 and 6,290,533 hectares respectively. Both rivers are approximately 600 km long.**
- **They comprise a vast assemblage of braided channels, waterholes, swamps, claypans, mound springs, shallow freshwater lakes and salt lakes.**
- **There are two internationally recognised RAMSAR sites along the Paroo River (Ramsar Convention Secretariat, 2006) and numerous sites in the catchments designated on the Directory of Important Wetlands in Australia.**

# *MODIS Channel Country and sub-set Paroo River Catchment March 14,2010*





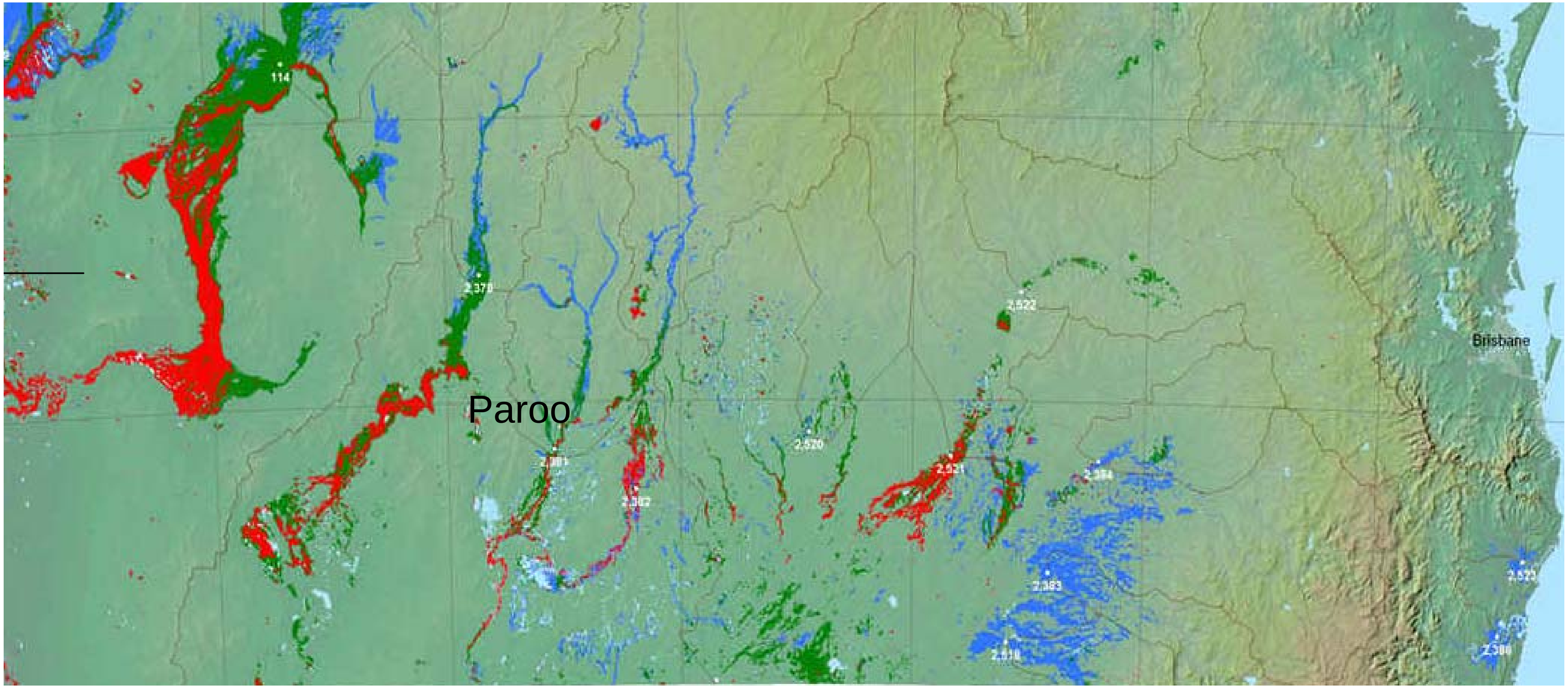

March14th 2010
6






Issued: 23/03/2010

# MODIS Multi-temporal Dataset

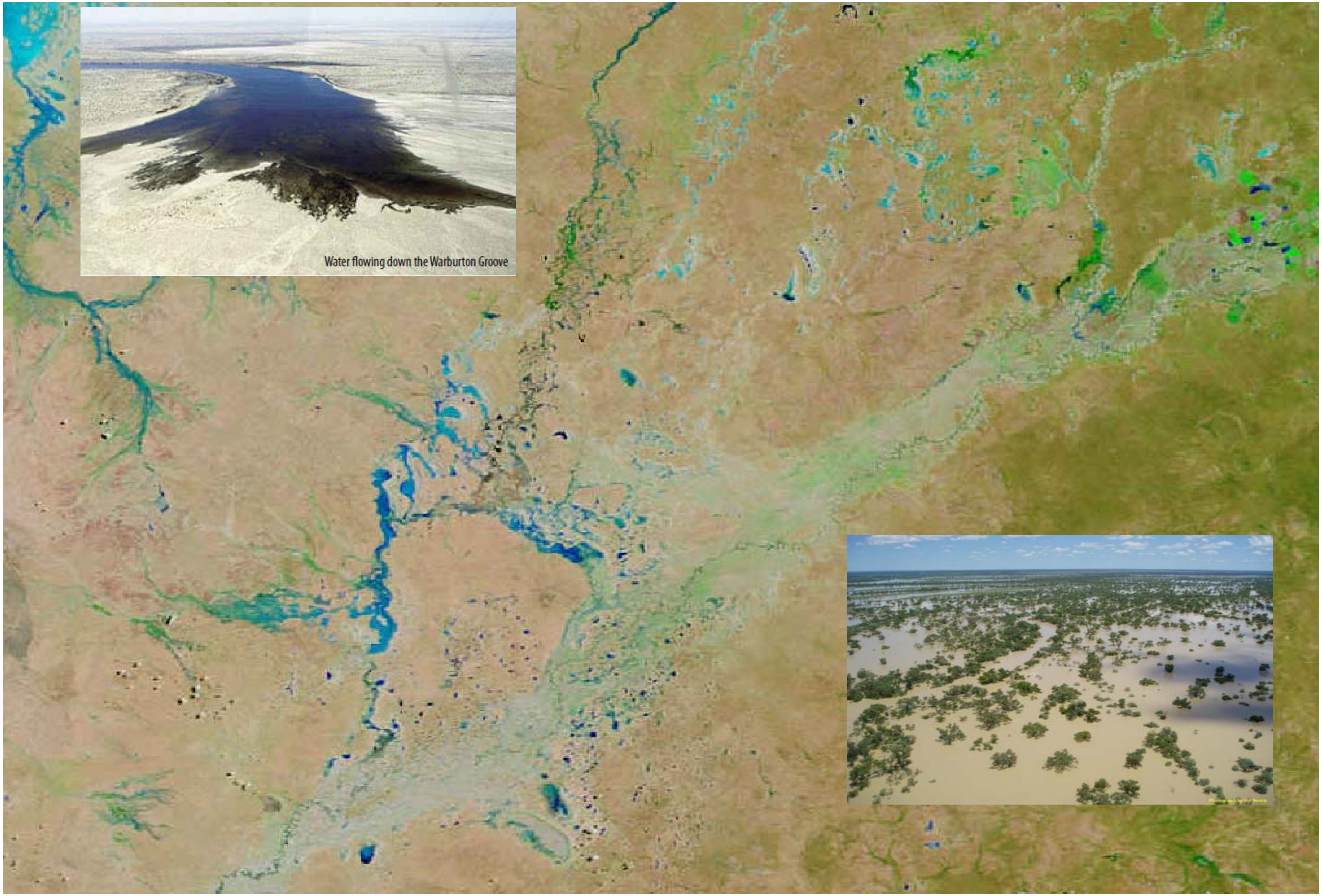



Current Flood Water*
March 13-14, 2010

Previous Floods:
2010

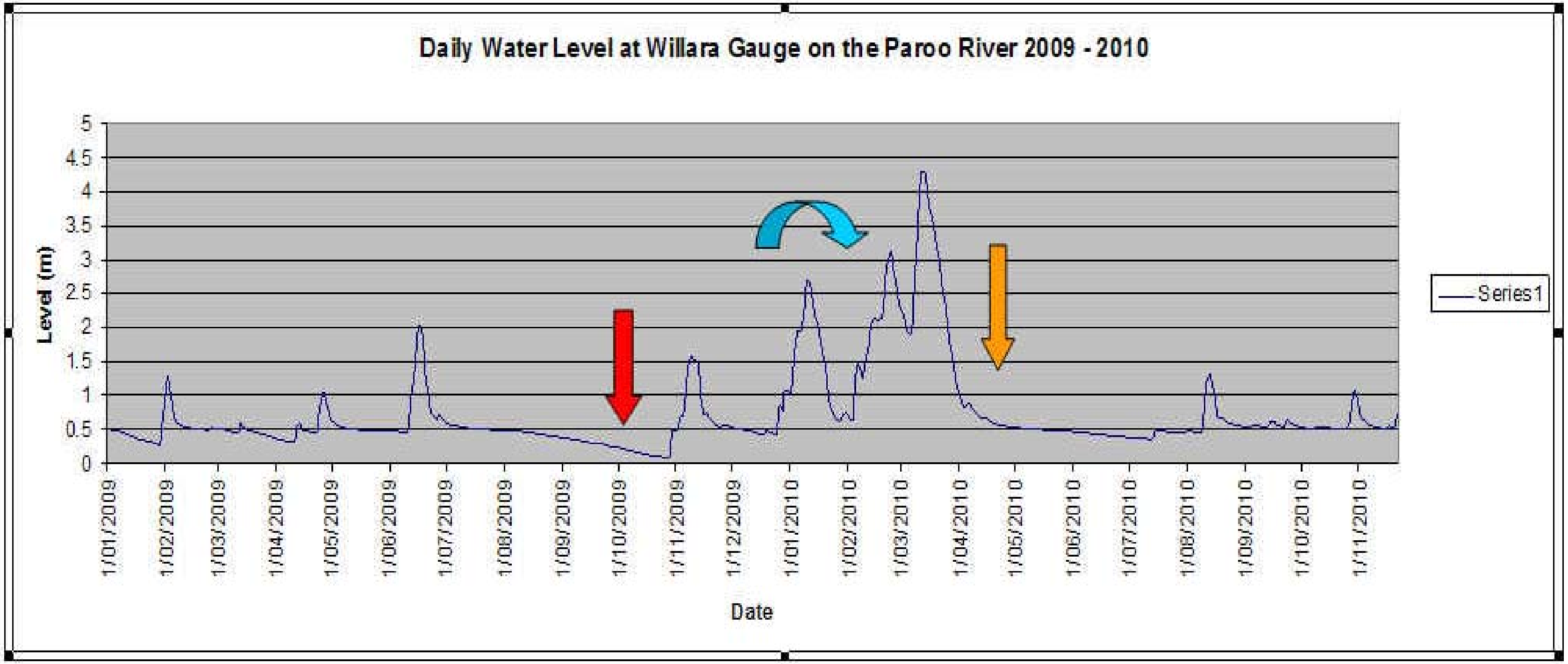
Previous Floods:
2000 - 2009

# *Paroo and Darling River Floods, March 2010*

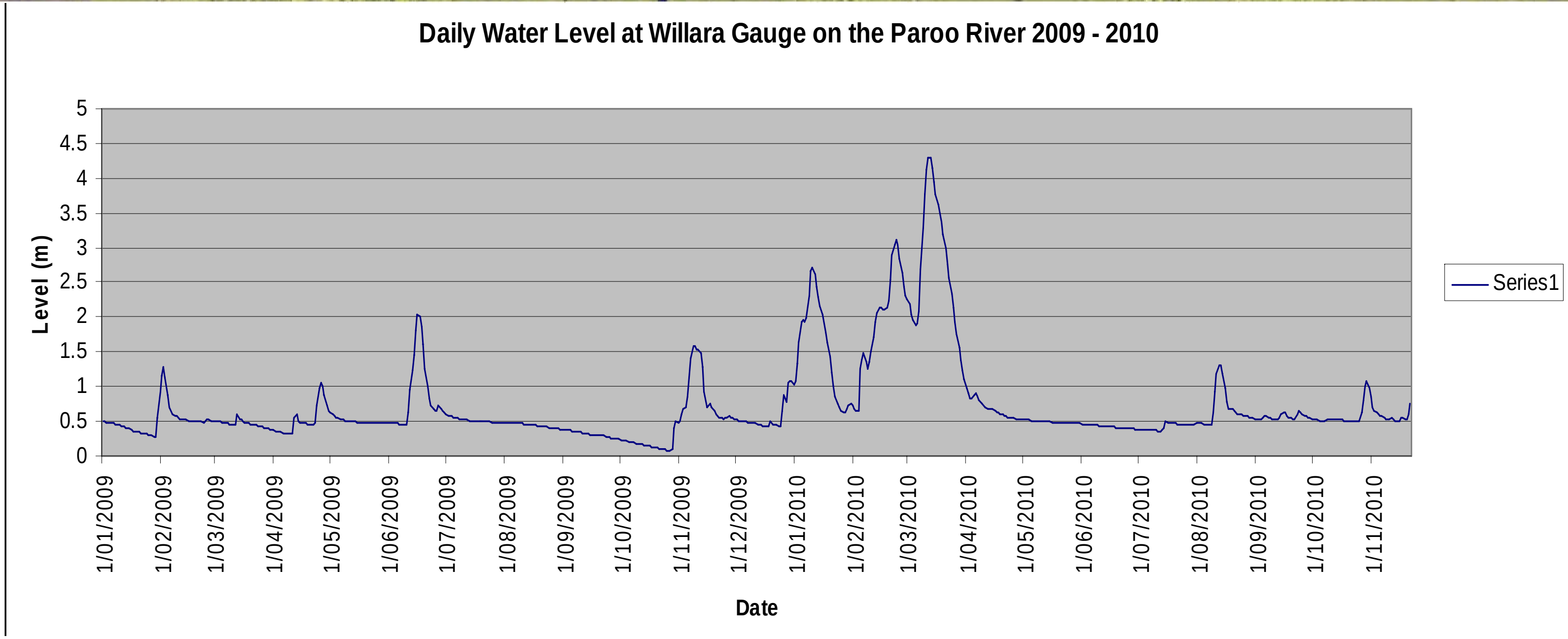


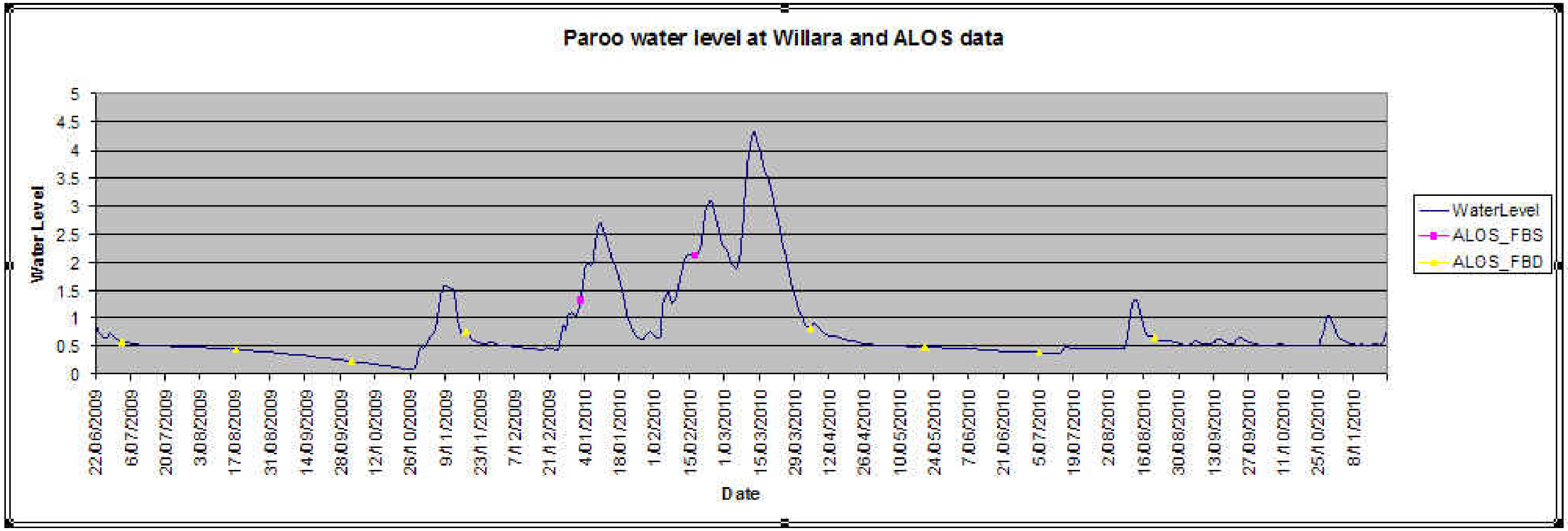
# *River Levels in the PAROO*

1. Willara Crossing on the Paroo River north of Hungerford NSW



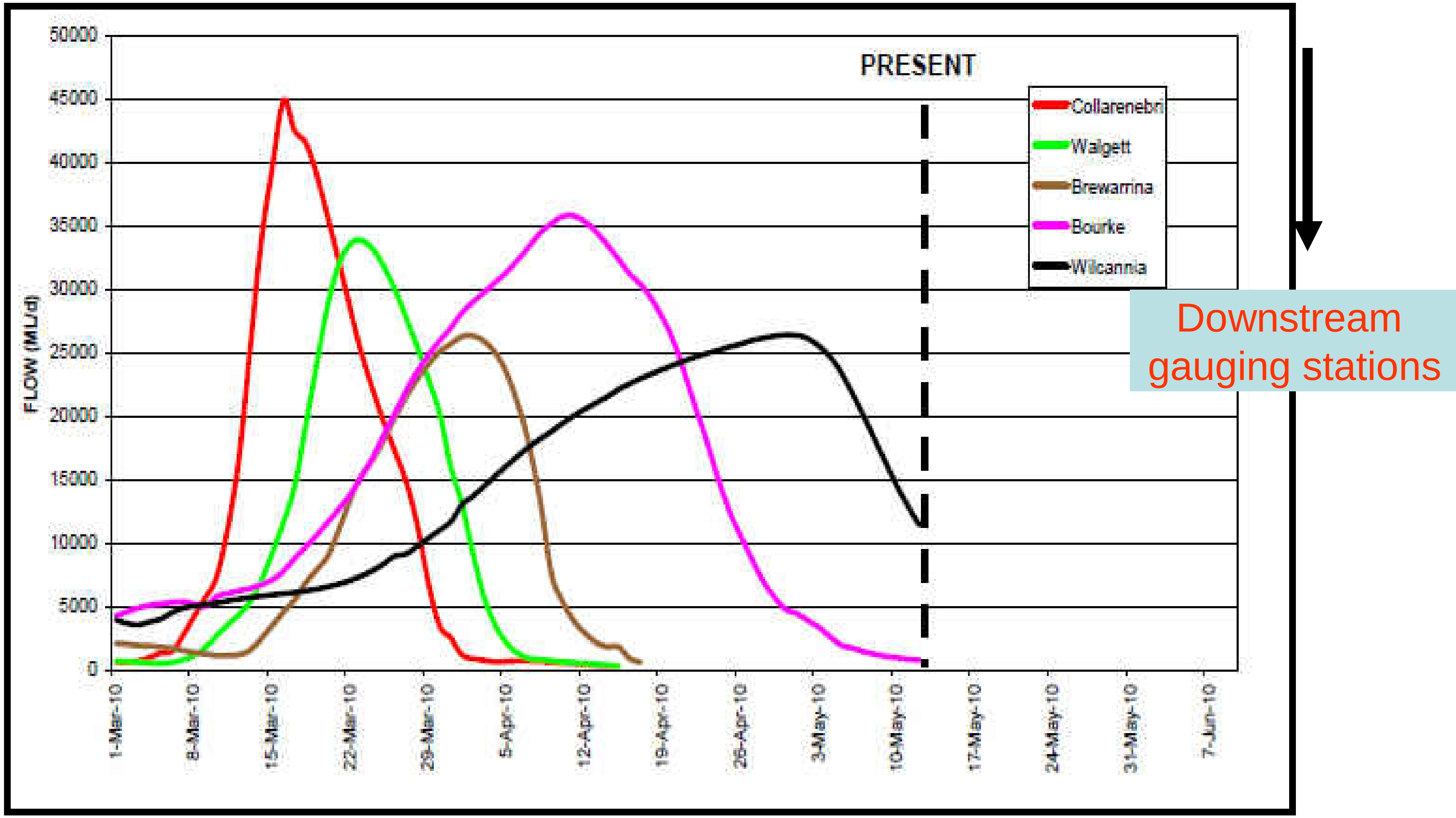

| Data required: see arrows on each graph |
|---|
| End of long dry period (before flood) |
| During wet period |
| During recession period as floodwaters recede and dry out |

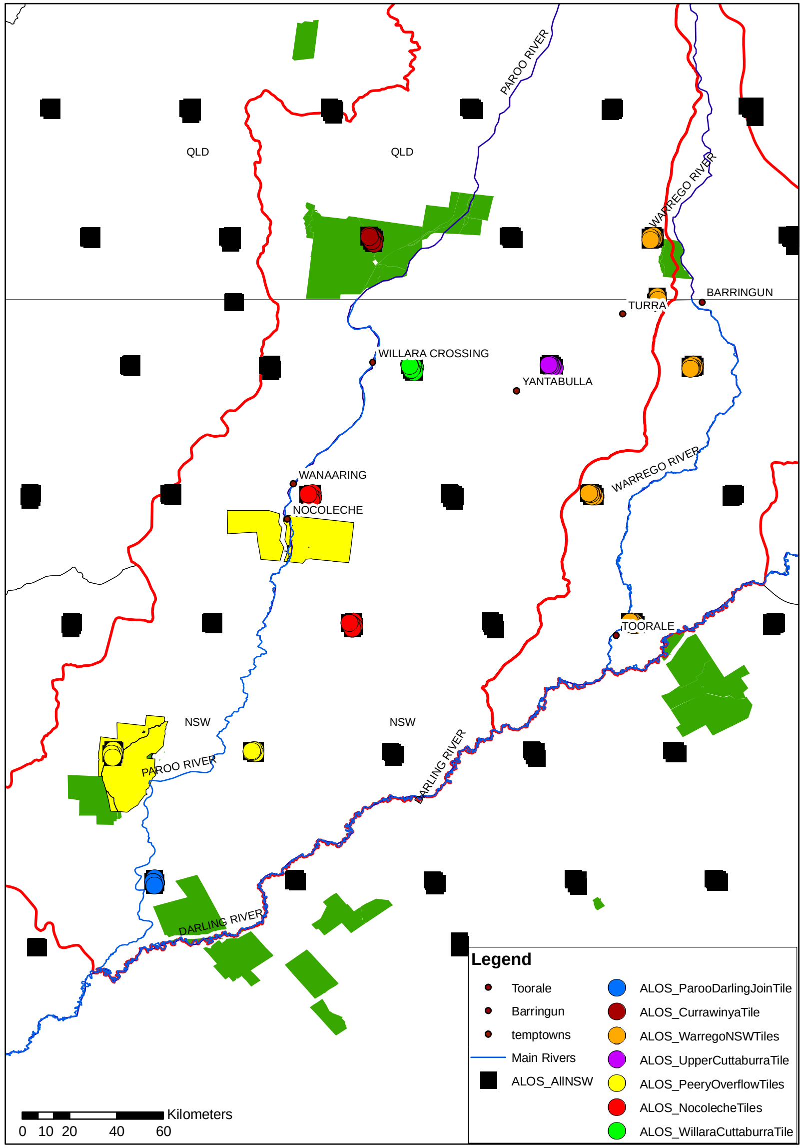

Daily Water Level at Willara Gauge on the Paroo River 2009 - 2010
Level (m)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
1/01/2009
1/02/2009
1/03/2009
1/04/2009
1/05/2009
1/06/2009
1/07/2009
1/08/2009
1/09/2009
1/10/2009
1/11/2009
1/12/2009
1/01/2010
1/02/2010
1/03/2010
1/04/2010
1/05/2010
1/06/2010
1/07/2010
1/08/2010
1/09/2010
1/10/2010
1/11/2010
Date
Series1


Paroo water level at Willara and ALOS data
Water Level
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
22/06/2009
6/07/2009
20/07/2009
3/08/2009
17/08/2009
31/08/2009
14/09/2009
28/09/2009
12/10/2009
26/10/2009
9/11/2009
23/11/2009
7/12/2009
21/12/2009
4/01/2010
18/01/2010
1/02/2010
15/02/2010
1/03/2010
15/03/2010
29/03/2010
12/04/2010
26/04/2010
10/05/2010
24/05/2010
7/06/2010
21/06/2010
5/07/2010
19/07/2010
2/08/2010
16/08/2010
30/08/2010
13/09/2010
27/09/2010
11/10/2010
25/10/2010
8/11/2010
Date
WaterLevel
ALOS_FBS
ALOS_FBD

ALOS K&C Initiative
An international science collaboration led by JAXA

# Following the Flood






# ***FBS-FBD***
# ***Data acquisition strategy***

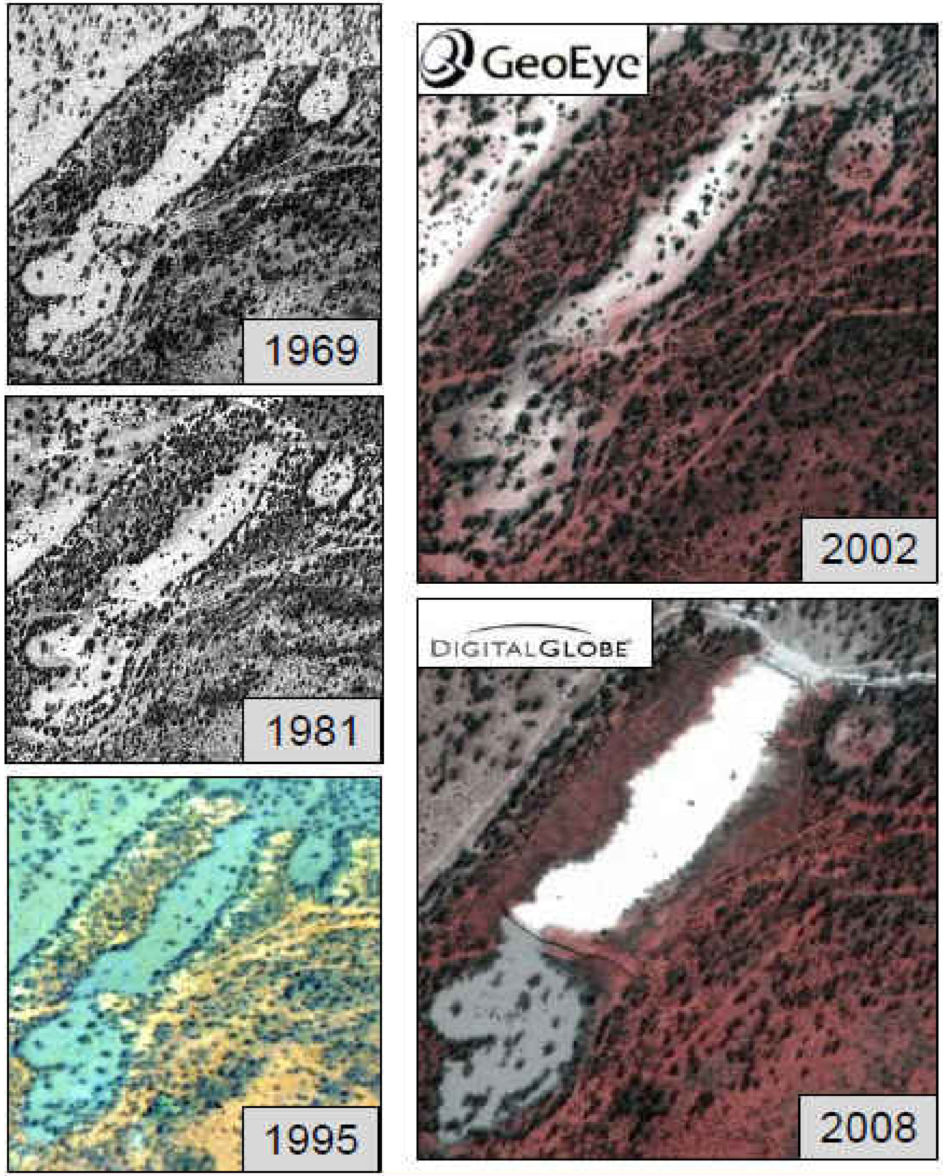
# *PALSAR Data Acquisition over  Willara*

**PALSAR scenes covering floodplain wetlands near Willara gauging station on the Paroo River 2009 - 2010 (see graph above) - Path 378 Frame 6590**

| Notes on obtaining data | Date | WaterLevel | ALOS_FBS | ALOS_FBD | SCNID | OPEMD | SCN_CDATE | PATHNO | CENFLMNO |
|---|---|---|---|---|---|---|---|---|---|
| | 2/07/2009 0:00 | 0.59 | | FBD | ALPSRP183136590 | FBD | 2/07/2009 | 378 | 6590 |
| | 17/08/2009 0:00 | 0.441 | | FBD | ALPSRP189846590 | FBD | ######## | 378 | 6590 |
| Obtain for end of dry period | 2/10/2009 0:00 | 0.229 | | FBD | ALPSRP196556590 | FBD | 2/10/2009 | 378 | 6590 |
| | 17/11/2009 0:00 | 0.759 | | FBD | ALPSRP203266590 | FBD | ######## | 378 | 6590 |
| ?FBS?Obtain for wet period | 2/01/2010 0:00 | 1.322 | FBS | | ALPSRP209976590 | FBS | 2/01/2010 | 378 | 6590 |
| ?FBS?Obtain for wet period | 17/02/2010 0:00 | 2.109 | FBS | | ALPSRP216686590 | FBS | ######## | 378 | 6590 |
| Obtain for end of wet period | 4/04/2010 0:00 | 0.83 | | FBD | ALPSRP223396590 | FBD | 4/04/2010 | 378 | 6590 |
| Obtain for recession period | 20/05/2010 0:00 | 0.482 | | FBD | ALPSRP230106590 | FBD | ######## | 378 | 6590 |
| Obtain for recession period | 5/07/2010 0:00 | 0.379 | | FBD | ALPSRP236816590 | FBD | 5/07/2010 | 378 | 6590 |
| Possible additional recession image | 20/08/2010 0:00 | 0.661 | | FBD | ALPSRP243526590 | FBD | ######## | 378 | 6590 |

**PALSAR scenes for Nocoleche RAMSAR site 2009 - 2010  (90km downstream of Willara - no gauging data)  - Path 379 Frame 6570**

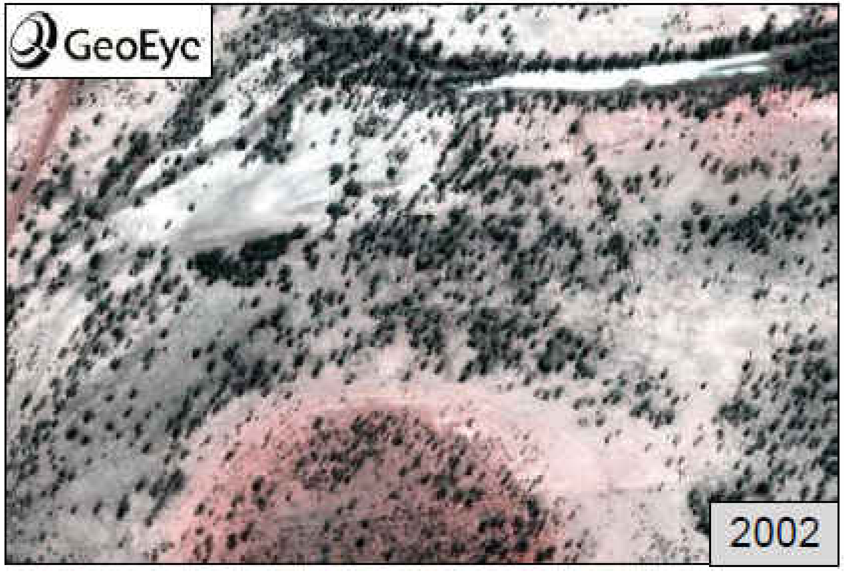
| Notes on obtaining data | SCNID | OPEMD | SCN_CDATE | PATHNO | CENFLMNO |
|---|---|---|---|---|---|
| | ALPSRP185616570 | FBD | 19/07/2009 | 379 | 6570 |
| Obtain for end of dry period | ALPSRP192326570 | FBD | 3/09/2009 | 379 | 6570 |
| | ALPSRP199036570 | FBD | 19/10/2009 | 379 | 6570 |
| Obtain for start of wet period | ALPSRP205746570 | FBD | 4/12/2009 | 379 | 6570 |
| ?FBS? Obtain for wet period | ALPSRP212456570 | FBS | 19/01/2010 | 379 | 6570 |
| Obtain for recession period | ALPSRP232586570 | FBD | 6/06/2010 | 379 | 6570 |
| Obtain for recession period* | ALPSRP246006570 | FBD | 6/09/2010 | 379 | 6570 |
| Obtain for recession period* | ALPSRP252716570 | FBD | 22/10/2010 | 379 | 6570 |



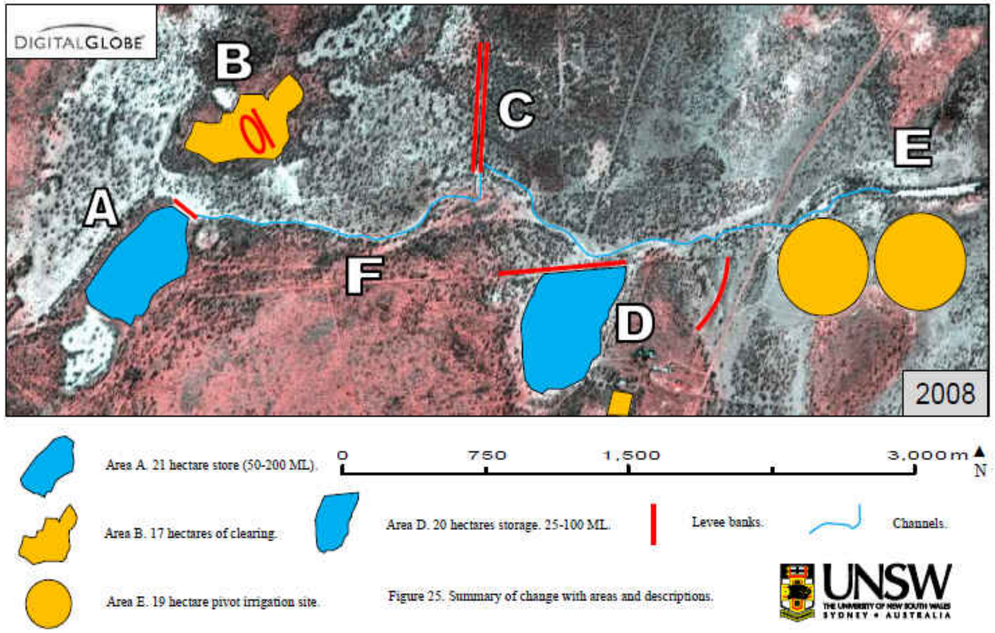

## *Transforming Wetlands Paroo River*

**Source Kingsford, 2007**

# Transforming Wetlands-
# Paroo River near Eulo



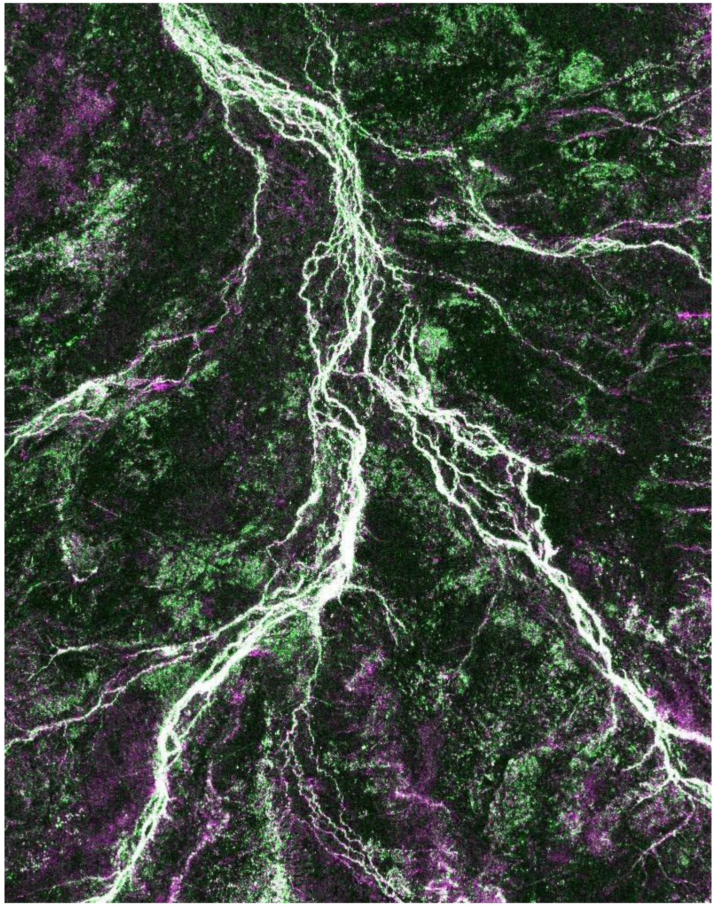





*Pivot irrigation each 19hct in area*

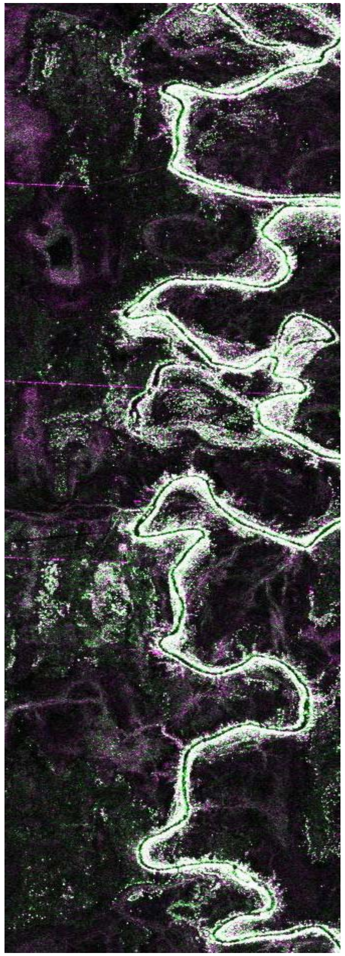
**Source Kingsford, 2007**

***L-Band ALOS PALSAR FBD and oblique photo (right) showing sheet-flooding where wide expanses of land are covered with shallow water.  Trees lining stream channels give high radar backscatter as a result of double bounce. Dark areas represent open water intermingled with islands and scattered tree cover.***



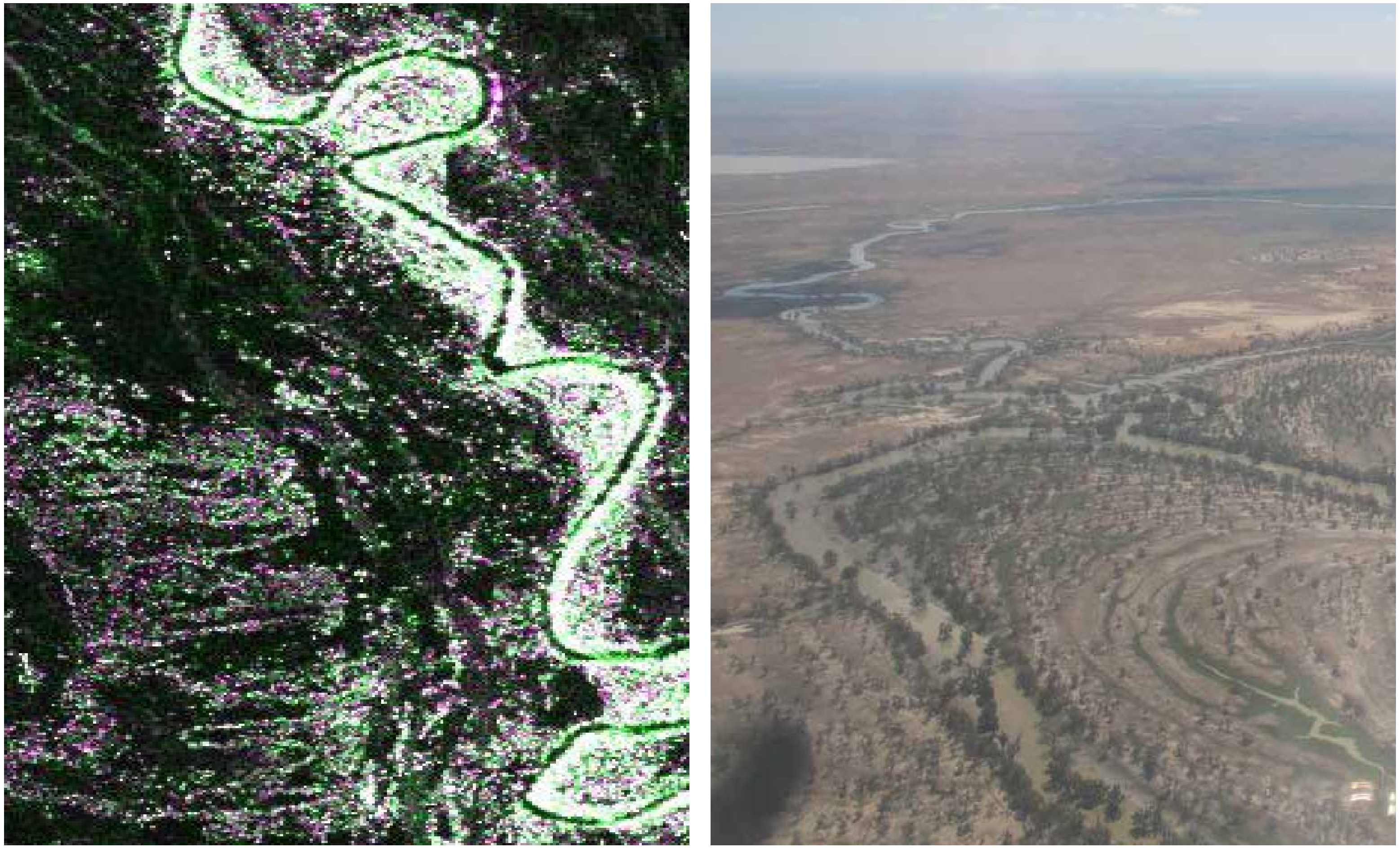


***L-Band ALOS PALSAR FBD (HH;HV;HH in RGB) sub–area (left) and Landsat insert (right) for comparison showing largely in-channel flow from increased discharge. The "gallery" effect of trees lining the channel bank gives high radar return***





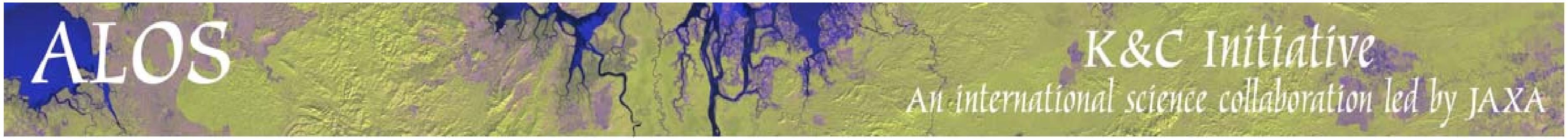
***L-Band ALOS PALSAR FBD (HH;HV;HH in RGB) sub–area (left) and oblique photo (right) showing overbank and floodplain inundation. Water is largely confined to the immediate stream valley and adjoining cut-offs and billabongs (Photo. Anthony Scott, 6 May 2010).***

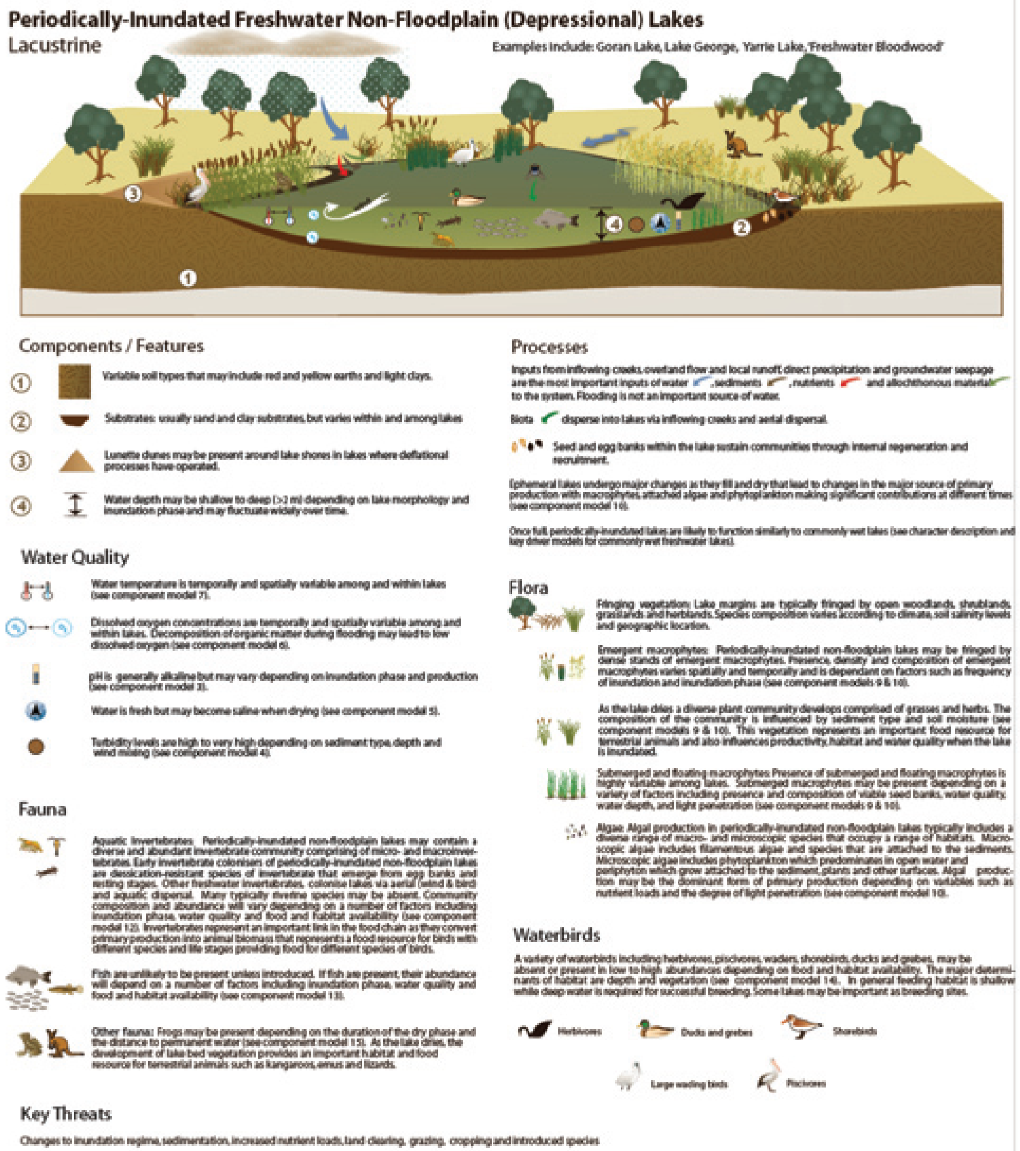


# *Morpho-ecological Mapping semi-arid wetland typologies*

## Categories

- » **Commonly wet freshwater lakes**
- » **Periodically-inundated floodplain freshwater lakes**
- » **Periodically-inundated non-floodplain (depressional) freshwater lakes**
- » **Floodplain freshwater swamps**
- » **Non-floodplain (depressional) freshwater swamps**
- » **Saline lakes**
- » **Saline swamps**



**Periodically-Inundated Freshwater Non-Floodplain (Depressional) Lakes**

Lacustrine

Examples include: Goran Lake, Lake George, Yarrie Lake, 'Freshwater Bloodwood'

### Components / Features

① Variable soil types that may include red and yellow earths and light clays.

② Substrates: usually sand and clay substrates, but varies within and among lakes

③ Lunette dunes may be present around lake shores in lakes where deflational processes have operated.

④ Water depth may be shallow to deep (>2 m) depending on lake morphology and inundation phase and may fluctuate widely over time.

### Water Quality

Water temperature is temporally and spatially variable among and within lakes (see component model 7).

Dissolved oxygen concentrations are temporally and spatially variable among and within lakes. Decomposition of organic matter during flooding may lead to low dissolved oxygen (see component model 6).

pH is generally alkaline but may vary depending on inundation phase and production (see component model 3).

Water is fresh but may become saline when drying (see component model 5).

Turbidity levels are high to very high depending on sediment type, depth and wind mixing (see component model 4).

### Fauna

Aquatic Invertebrates: Periodically-inundated non-floodplain lakes may contain a diverse and abundant invertebrate community comprising of micro- and macroinvertebrates. Early invertebrate colonisers of periodically-inundated non-floodplain lakes are desiccation-resistant species of invertebrate that emerge from egg banks and resting stages. Other freshwater invertebrates, colonise lakes via aerial (wind & bird) and aquatic dispersal. Many typically riverine species may be absent. Community composition and abundance will vary depending on a number of factors including inundation phase, water quality and food and habitat availability (see component model 12). Invertebrates represent an important link in the food chain as they convert primary production into animal biomass that represents a food resource for birds with different species and life stages providing food for different species of birds.

Fish are unlikely to be present unless introduced. If fish are present, their abundance will depend on a number of factors including inundation phase, water quality and food and habitat availability (see component model 13).

Other fauna: Frogs may be present depending on the duration of the dry phase and the distance to permanent water (see component model 15). As the lake dries, the development of lake bed vegetation provides an important habitat and food resource for terrestrial animals such as kangaroos, emus and lizards.

### Processes

Inputs from inflowing creeks, overland flow and local runoff, direct precipitation and groundwater seepage are the most important inputs of water, sediments, nutrients and allochthonous material to the system. Flooding is not an important source of water.

Biota disperse into lakes via inflowing creeks and aerial dispersal.

Seed and egg banks within the lake sustain communities through internal regeneration and recruitment.

Ephemeral lakes undergo major changes as they fill and dry that lead to changes in the major source of primary production with macrophytes, attached algae and phytoplankton making significant contributions at different times (see component model 10).

Once full, periodically-inundated lakes are likely to function similarly to commonly wet lakes (see character description and key driver models for commonly wet freshwater lakes).

### Flora

Fringing vegetation: Lake margins are typically fringed by open woodlands, shrublands, grasslands and herblands. Species composition varies according to climate, soil salinity levels and geographic location.

Emergent macrophytes: Periodically-inundated non-floodplain lakes may be fringed by dense stands of emergent macrophytes. Presence, density and composition of emergent macrophytes varies spatially and temporally and is dependant on factors such as frequency of inundation and inundation phase (see component models 9 & 10).

As the lake dries a diverse plant community develops comprised of grasses and herbs. The composition of the community is influenced by sediment type and soil moisture (see component models 9 & 10). This vegetation represents an important food resource for terrestrial animals and also influences productivity, habitat and water quality when the lake is inundated.

Submerged and floating macrophytes: Presence of submerged and floating macrophytes is highly variable among lakes. Submerged macrophytes may be present depending on a variety of factors including presence and composition of viable seed banks, water quality, water depth, and light penetration (see component models 9 & 10).

Algae: Algal production in periodically-inundated non-floodplain lakes typically includes a diverse range of macro- and microscopic species that occupy a range of habitats. Macroscopic algae includes filamentous algae and species that are attached to the sediments. Microscopic algae includes phytoplankton which predominates in open water and periphyton which grow attached to the sediment, plants and other surfaces. Algal production may be the dominant form of primary production depending on variables such as nutrient loads and the degree of light penetration (see component model 10).

### Waterbirds

A variety of waterbirds including herbivores, piscivores, waders, shorebirds, ducks and grebes, may be absent or present in low to high abundances depending on food and habitat availability. The major determinants of habitat are depth and vegetation (see component model 14). In general feeding habitat is shallow while deep water is required for successful breeding. Some lakes may be important as breeding sites.

Herbivores | Ducks and grebes | Shorebirds | Large wading birds | Piscivores

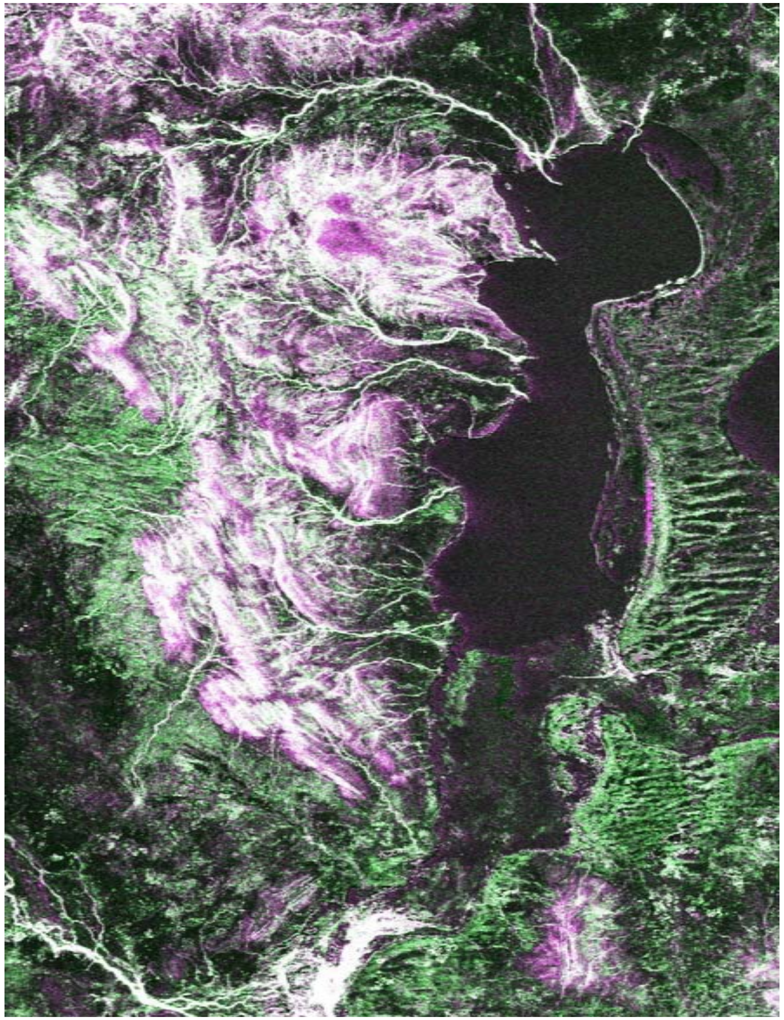
### Key Threats

Changes to inundation regime, sedimentation, increased nutrient loads, land clearing, grazing, cropping and introduced species

# *Wetland Conceptual Models for the Semi-Arid Zone*

**Source: A. Price & B. Gawne, 2009**

L-Band ALOS PALSAR  FBD (HH;HV;HH in RGB) sub–area (left) and Landsat insert (right) of Lake Peery which is the largest overflow lake on the Paroo River. It is approximately 15km long and covers over 5,026 hectares when in flood. The lake is bordered by sedimentary ranges on the west and sand dunes and sand plains on the east and is a RAMSAR listed site. The Lake is fed by floodwaters passing down the Paroo River. © *JAXA/MET*





# Ongoing Work

- ***Twenty-five PALSAR scenes are currently being analysed to further this investigation.***

- ***These include images from 2/10/2009 which is the driest date before the February-March 2010 flood.***

- ***Other scenes cover the flood peaks (17/11/2010-17/02/2010) and the recession period (4/4/2010-20-08/2010).***

- ***Also, an extensive fieldwork program has been initiated in order to survey vegetation communities and examine their resilience to the changing flood conditions and to validate image interpretation and analysis of the geomorphological classes identified.***

# *Conclusions*

- ***Multi-temporal data stacks can yield more information about changing surface dynamics than single scene acquisitions and are necessary to capture environmental changes and help quantify bio-physical processes.***
- ***Given the severe 10 year drought Australia has been experiencing (2000-2010), there have been few flood events on inland river systems that would permit the identification of wetland types and none within the current lifetime of the ALOS sensors until early 2010.***
- ***Where possible historical data from other sensors will be used to examine and supplement the historical record.***

# K&C deliverables
# Papers and Reports

- **K&C Phase-1 and Phase 2 reports**
- **Contribution to K&C Booklet**
- ***Use of L-band radar to interpret inundation patterns in the Macquarie Marshes and Gwydir Wetlands* (Version 2) Internal Report prepared by HGC, UNSW CRC-SI and DECC, November 2007. Updated, January 2011. pp76.**


- **Milne, A., Tapley, I., Mitchell, A., (2009*),  Multiband Radar For Mapping Inundation Patterns In Semi-Arid Wetland Environments; Macquarie Marshes, New South Wales,* Proceedings, IEEE International Geoscience and Remote Sensing Symposium, (IGARSS 2009), Capetown, South Africa, 12-17 July,2009.**

- **Williams, M., Milne A., Tapley, I.,  Carson, T., Reis, J., Sanford, M., Kofman, B., Hensley, S., (2009), *Tropical Forest Biomass Recovery Using GeoSAR Observations,* Proceedings, IEEE International Geoscience and Remote Sensing Symposium, (IGARSS 2009), Capetown, South Africa, 12-17 July,2009.**

- **Mitchell, A.,  Milne, A., Tapley, I., Lowell, K., Caccetta, P., Lehmann, E., Zhou, Z., Held, A., (2010), *Mapping of Forest Extent and Change in Tasmania using ALOS Palsar Data in Support of the GEO Forest Carbon Tracking*, European Space Agency Living Planet Symposium, Bergen, Norway, 28 June-2 July 2010.**

- **Mitchell, A., Milne, A., Tapley, I., Lowell, K., Caccetta, P., Lehmann, E., Zhou, Z., (2010),*Wall-to-Wall Mapping of Forest Extent and Change in Tasmania using ALOS Palsar Data,* Proceedings, IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2010), Honolulu, Hawaii, July 2010.**

- **Mitchell, A., Tapley, I., Milne, T., Lowell, K., (2010), *Forest Type Degradation Mapping in Tasmania using ALOS PALSAR Data,* Proceedings: 15th Australasian Remote Sensing and Photogrammetry Conference,13-17 September, 2010 Alice Springs, Australia. CD-ROM.**


## Submitted/in preparation


- **Lowell, K., Mitchell, A., Tapley, I., Milne, A., Caccetta, P., Lehmann, E., Zhou, Z., Held, A., (2011), *Interoperability Of Imagery For Land-Use Change: Examples From Optical And Radar Data,* (International Geoscience and Remote Sensing Symposium (IGARSS 2011), 1-5 August, Sendai, Japan**

- **Mitchell, A., Milne, A., Tapley, I., Lowell, K., Caccetta, P., Lehmann, E., Zhou, A., Held, (2011) , *Key outcomes of the Tasmania 'National Demonstrator': A Project for the GEO Forest Carbon Tracking Task,* 34th International Symposium Remote Sensing of Environment, 10-15 April, 2011, Sydney, Australia.**

# K&C deliverables

Data sets and Thematic products
(Not yet available)