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

Anthony K Milne
School of Biological, Earth and Environmental Sciences,
University of New South Wales, Sydney, NSW 2052, Australia, Tony.Milne@unsw.edu.au

Ian J Tapley
Horizon Geoscience Consulting Pty Ltd, 12 Viewcrest Way, Sorrento, 6020, WA, Australia.
HGCiant@bigpond.net.au

Abstract— **It is well documented that 24cm wavelength JERS-1 and ALOS PALSAR L-band radar data are well suited to map and monitor the structural assemblage of dense vegetation cover comprising shrublands and forests. In addition, the penetration capability of L-band enables accurate detection and mapping of flooding below forest canopy. In this on-going study, ALOS-PALSAR and archival JERS-1 SAR imagery are used in conjunction with complementary datasets and field-data to develop a baseline inventory for showing the extent of flooding in the Lower-Mekong Basin in South East Asia and to analyse flood patterns in the Macquarie Marshes located in the Murray-Darling Basin in eastern Australia. These baselines will then be used to monitor subsequent seasonal changes in the extent and duration of flooding. Attention is also paid to mapping and monitoring changes in the status and condition of wetland vegetation types in these two river basins.**

***Index Terms*—ALOS-PALSAR, JERS-1 SAR, K&C Initiative, wetlands, Lower Mekong Basin, Murray-Darling Basin**

I. INTRODUCTION

The Project focuses on two contrasting wetland environments: the wet-tropical Lower Mekong Basin in Southeast Asia, and the semi-arid Macquarie Marshes in the Murray-Darling Basin. Both regions are under threat from anthropogenic disturbances and from the impacts of projected climate change. Foremost among these influences are landscape degradation and declining water availability.

In this on-going project, ALOS-PALSAR and archival JERS-1 SAR imagery are used in conjunction with complementary datasets and field-data to develop a baseline inventory for showing the extent of flooding in the two study sites against which subsequent seasonal changes in the extent and duration of flood events can be mapped and assessed. Attention has also been paid to mapping and monitoring the changes in wetland vegetation types.

Within the Lower Mekong Basin (LMB), future significant changes in river flow and total discharge can expected to occur as a result of dam building in the upper reaches of the Basin. Land use and environmental planning will therefore be intimately linked and to a large extent controlled by changing river flow regimes which are likely to seriously alter the seasonal passage of discharge through the LMB.

Within the Murray Darling Basin (MDB) there are a number of freshwater Ramsar-listed wetland sites including the Macquarie Marshes, the Gwydir wetlands and the Murrumbidgee wetlands [1]. These, along with other riverine wetlands in eastern Australia, have experienced significant long-term declines in stream flow as a result of river regulation and water storage diversions to support irrigated agriculture.

II. STUDY AREAS

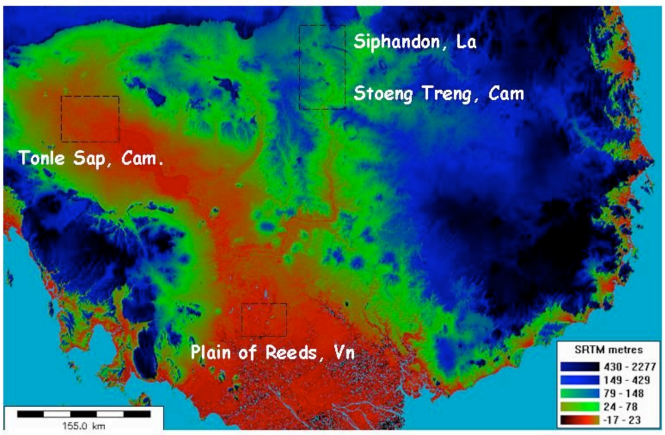

Figure 1. SRTM DEM showing location of study sites within Lower Mekong Basin

A. Lower Mekong Basin

Within the LMB analyses of PALSAR and JERS radar datasets have focused on 4 sites: Siphandon in Lao PDR, Stoeng Treng and Tonle Sap in Cambodia, and Tram Chim in the Mekong Delta of Vietnam. Wetland sites along the Songkram River floodplain, Thailand, and within Attepeu Province, Lao PDR, are yet to be included in the analysis. Siphandon and Stoeng Treng are sites along the Mekong River under threat from the development of hydro-electric dams and modification to the extent of flooded forests and disruption to the fish habitats proximal to the river channels.

Tonle Sap is the most important wetland in Southeast Asia in terms of productivity and biodiversity [2] and [3]. In addition to impacts of illegal forest logging, it too is threatened by the future availability of floodwaters which are likely to be insufficient to support Cambodia's demand for irrigated rice growing and for the supply of fish stocks.

Tram Chim National Park is a remnant wetland, representative of the ecosystem that formerly occupied the vast Plain-of-Reeds. Threats to its sensitive biodiversity include modification of the water regime in the Mekong Delta, inappropriate fire-control measures, fires, chemical pollution from agriculture development, acidification of water bodies by digging and exposure of acid-sulphate soils, and illegal logging of the natural *Melaleuca spp*. forests.

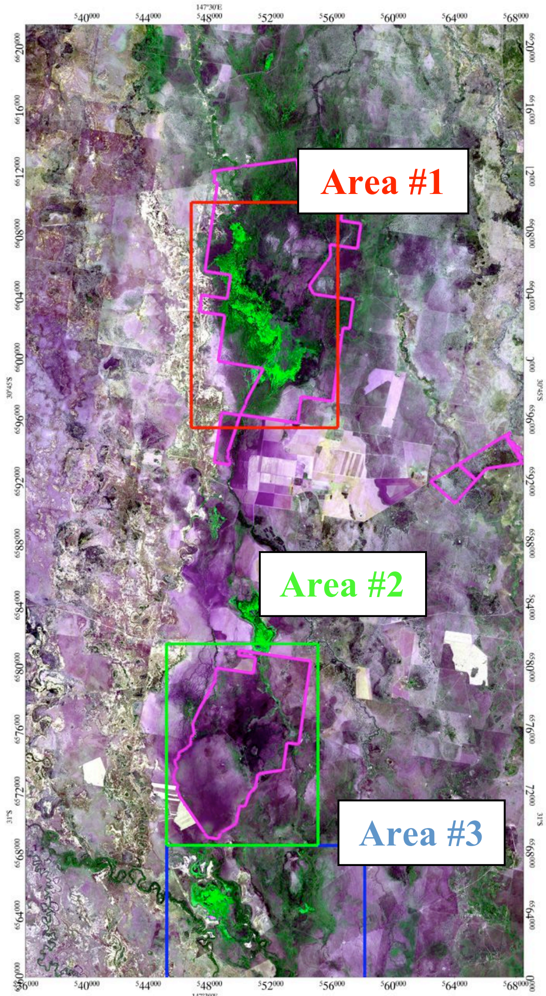

Figure 2. Target areas in the Macquarie Marshes overlain on SPOT-5 imagery (bands Red:NIR:Green in R:G:B): Area 1 (red) in the northern reserve; Area 2 (green) in the southern reserve; and Area 3 (blue) to the south of the marshes. The boundary of the Macquarie Marshes Nature Reserve is shown in magenta.

B. Macquarie Marshes

The Macquarie Marshes constitute an inland semi-permanent wetland located in the Macquarie River Catchment in central-western NSW. The wetlands have formed within an alluvial fan system which is characterised by a series of anastomosing channels running through the marshes [4]. The streams eventually drain into the Darling River (Figure 2). The Marshes depend on the inflow of water coming from up-river and outside the immediate area for their maintenance and ecological survival. In this respect they differ markedly from the Mekong wetlands which receive seasonal rainfall and an annual inflow of floodwaters in the monsoon season.

In the case of the Macquarie Marshes, 40-50% of the wetlands have already been lost and overall <10% of the original wetlands are considered healthy. Together with the impact of continued drought and water being diverted for irrigation, water availability to the marshes and inflow into this river system in general is limited to the release of controlled environmental flows from upstream.

III. PROJECT DESCRIPTION

A. Lower Mekong Basin

Objective: To detect changes in the magnitude and frequency of flood events, and identify land cover changes over selected wetland sites in the Lower Mekong Basin using a time-series of JERS-1 and PALSAR datasets.

Specific aims include:

i. Examine relative contributions of HH and VV polarizations to discriminate between wetland types;
ii. Examine data for details of wetlands, generate site specific maps of wetland type and land cover change;
iii. Create hydro-pattern maps based on individual scenes to show extent of flooding and relative water heights;
iv. Merge multiple datasets and look at spatial variations in backscatter signatures over the temporal domain.;
v. Determine disturbance parameters in the selected wetland ecosystems through land development, land clearing for rice paddies, road constructions and water diversion;
vi. Analyse for changes in wetland type and extent and impacts of disturbance.
vii. Undertake field validation of image-map products with a revisit to nominated field sites and spot-checks of additional sites of interest identified in the imagery.

Complex seasonal cycling involved in the change from wet-to-dry conditions is not captured in a single date image. This problem is resolved using multi-date imagery resulting in the likelihood of a much improved classification and monitoring scheme.

Products to be derived from this K&C Initiative include image-maps of wetland cover and of annual changes in wetland cover, along with flood maps showing flood extent and seasonal floodwater recession patterns.

B. Macquarie Marshes, Australian Murray-Darling Basin

Objective: To undertake a multi-scene stack analysis of 20+ scenes of PALSAR data to identify hydrologic and vegetation response to changed flood and in-channel discharge conditions in a semi-arid environment.

Specific aims include:

i. Process a registered and calibrated time-series PALSAR dataset of both FBS and FBD imagery acquired over a 3-5 year time period.
ii. Apply suitable image processing routines to enable class discrimination to be established between open water, saturated soil areas, bare ground and seasonal grasslands.
iii. Apply suitable image processing routines to enable class separation between different wetland vegetation types, assess vegetation condition over time.
iv. Relate class separation to periodicity and magnitude of flood events occurring over the same period.

This study is assessing PALSAR FBS data for detecting surface water beneath tree canopies and for monitoring the impact of environmental flow on soil moisture and vegetation response and condition in these marshes [5] and [6].

Ultimately, the Project aims to demonstrate the benefits of incorporating SAR into an operational system for monitoring flooding, wetland and landuse dynamics, and assessing the impacts of climate change in this semi-arid environment. This will be accomplished when a longer time-series of imagery becomes available.

IV. METHODOLOGY

The principal datasets for both investigations include JERS-1 L-band wavelength, HH-polarization for the period 1992-98, and Fine-Beam PALSAR L-band wavelength, HH- and HV-polarization collected for period 2006-2009. ScanSAR strip data at 50m resolution is now available but has not yet been processed. An important aspect of the Macquarie Marshes study is an evaluation of X-band (Terra-SAR) and C-band (Radarsat-1) datasets with PALSAR acquired for near corresponding dates. HyMap hyperspectral data and field observations complement the Macquarie Marshes radar data.

In the LMB SRTM height data and time-series radar data was used for hydrological and wetland dynamic studies, complemented with high-resolution optical imagery and stream-gauging information for flood assessment.

PALSAR and JERS image intensity data were provided by JAXA as calibrated datasets. Each was subsequently adjusted to dB values using the documented techniques allowing direct comparison between processed data of each system.

Initial assessment of the map geometry supplied in the header file for each JERS and PALSAR scene showed the coordinates to be unreliable. Therefore considerable time was spent geolocating each scene to UTM map projection using ground-control points selected from a reference optical scene. Final registration accuracy was <1 pixel. Multi-date scenes of JERS and PALSAR were assembled for each study site into a stack of registered scenes suitable for time-series analysis.

Image enhancement and information extraction procedures used include; single-date grey-tone images, ratio greytone images, RGB colour-composite images of multiple dates and polarizations, data transforms, change detection, multivariate analysis, segmentation and classification.

Advanced processing techniques were applied to quantify the land-cover and determine how the cover classes alter over time in response to variations in local topography, climatic change and anthropogenic impacts such as forest and wetland clearing, flooding, reduced water availability and urbanization.

V. RESULTS

A. Lower Mekong Basin

The capacity to map and monitor the incidence of seasonal flooding in the LMB as well as observe the larger regional responses to seasonal change are shown in Figure 3. These ScanSAR images (50 metre resolution) for 5th November, 2006, which marks the end of the wet season, records the extent of flooding in the Tonle Sap Lake. The inflow of water comes from the flooded Mekong River. Tonle Sap occupies the bottom of a shallow basin with water levels peaking at around 6-8 metres above sea level at peak flood height when the capacity of the lake increases fourfold.

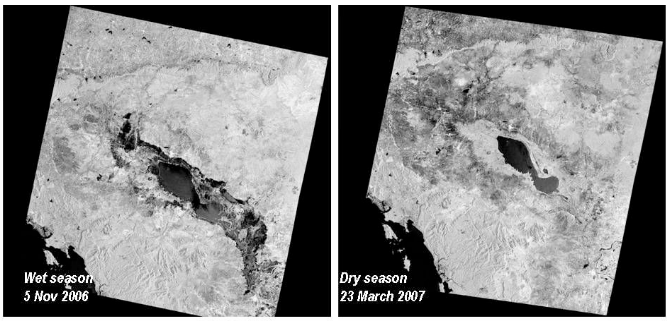

Figure 3. ScanSAR images of Tonle Sap Great Lake in Cambodia showing seasonal flood extent, wetlands and permanent surface water. Comparison indicates the extent of flooding during the wet season and open surface water bodies in the dry season. © JAXA/METI

The dry season image for 23March 2007 in contrast shows a shrunken lake area as the floodwater drains back into the main channel of the Mekong River. This annual reversal of flow dominates the ecological and human response to the prevailing environmental conditions. The expanded dark areas in the March image away from the lake and adjoining wetlands are a backscatter response from dry rice paddies and bare fields.

Figure 4 shows in more detail the impact of flooding and the effect of falling lake levels along the western end of the Tonle Sap Lake. Extensive areas of wetland forest are covered by water in the wet season but have 'emerged' as the water level in the lake falls to its lowest in the dry season. Detailed mapping and classification of this wetland is given in [2].

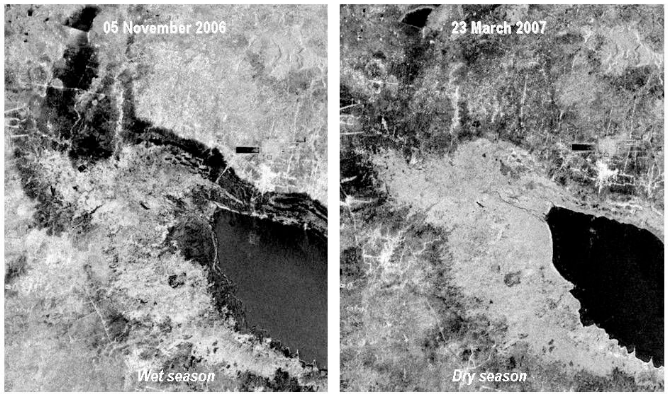

Figure 4. Northern end of Tonle Sap Great Lake - ScanSAR images acquired during the wet (November) and dry (March) seasons show clearly the seasonal differences in the level of water in the lake and also highlight flooding under tree canopies, especially apparent in the wet season.
© JAXA/MET

Calibration of JERS-1 and PALSAR into a multi-temporal dataset spanning the period 1992-2007 permits the analysis of landscape change over a much longer period.

Figure 5 displays a time-series colour-composite image of JERS-1 Sept.1992, JERS-1 Sept.1998 and PALSAR Sept.2007 as RGB, respectively. This image shows a consistency in the flood pattern of the Mekong River for the September time-frame which is the height of the wet monsoon season. The adjacent scene is a difference image from calibrated scene backscatter data for Sept 1992 and 2007. Increases or decreases in backscatter are shown in db.

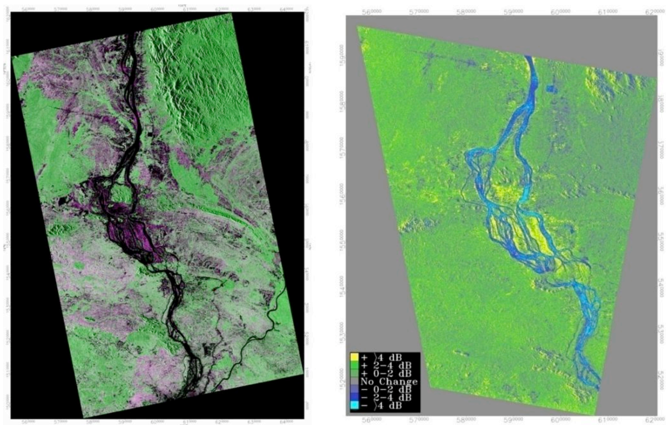

Figure 5. Siphandon, Lao PDR:
Left image: time-series RGB colour-composite image comprising JERS (Sept.1992) : JERS (Sept.1998) : PALSAR (Sept.2007), respectively.
Right image: change detection over a 15 year period, Sept.1992 to Sept.2007. Increase in biomass, maturation of rice crops etc. are shown in yellow; a general increase in the level of foliage cover as green; water surfaces, rough (Sept.1992) and smooth (Sept.07) as cyan-blue, and transport routes as blue. © JAXA/METI

The capacity to use PALSAR data to capture seasonal and intra-annual change in landscape dynamics information is depicted in Figure 6. Here a mid-dry season image (January), an end of dry season image (March) and an early wet season image (September) from 2007 are combined allowing discrimination of more land cover types than is possible with a single-date image.

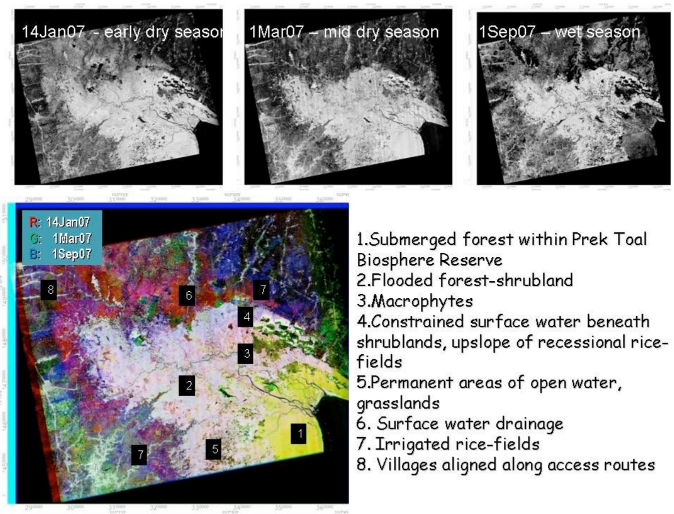

Figure 6. Three-date colour composite image of the Prek-Toal Nature Reserve, Cambodia. The colour and hues are in response to changing backscatter conditions that occur as a result of falling water levels and crop phenology. *© JAXA/METI*

Figure 7 shows the relative changes that have occurred over a fifteen year period (1992-2007). While the dataset has not yet been classified, an intuitive interpretation of some of the probable changes in land cover that have taken place at selected locations is noted with the image.

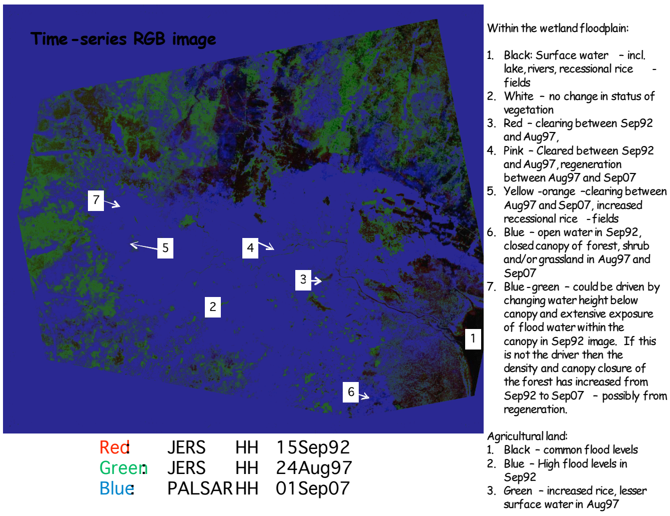

Figure 7. Tonle Sap change image resulting from the RGB combination of JERS-1 Sept. 92, JERS-1 Aug.97 and PALSAR Sep.07 - possible changes identified are described for seven locations. © JAXA/METI

A more detailed analysis in landscape change in the LMB awaits the availability of an extended PALSAR time series from the 2009 -2011 period.

B. Murray-Darling Basin

Vegetation cover in the Macquarie Marshes is must less luxuriant than that found in the LMB. Here sedges, shrubs and grassland dominate with eucalypt (River Red Gum) forests aligning the waterways, with occasional open woodlands on the periphery of the forest stands.

Analysis of PALSAR data acquired over the Macquarie Marshes in 2006, 2007 and 2008 was centred on the impact of a single flood event in January 2008. From available stream discharge records, it is not clear if in fact and to what extent overbank flows occurred within the marshes. In addition to identifying flooded forest wetlands, determining the inundation pattern, detecting areas of increased surface soil moisture and ephemeral vegetation growth on the floodplain, also became drivers in this analysis.

Flooded forests are easily recognised in PALSAR data by their bright response and enhanced backscatter at L-band HH polarisation as a result of penetration of the tree canopy and double-bounce interactions between the large branches and trunks and the underlying, highly reflective inundated surface. Strong returns from single-bounce interactions at HH and HV polarisation with large branches and trunks are also observed.

In the single-date image shown in Figure 8, areas of flooded forest are bright. Ponded areas and open water in channels (black on image) are scattered throughout the wetlands, including water flowing into the River Red Gum forest (purple arrow), Loudens lagoon (red arrow), Third Crossing Lagoon (orange arrow) and Bora Creek (blue arrow). The dark patches on the western side of the image comprise old river channels and scalded bare ground. Water has accumulated in the depressions and flat scalded areas forming a thin film of mud that induces a specular response, and so these areas appear black.

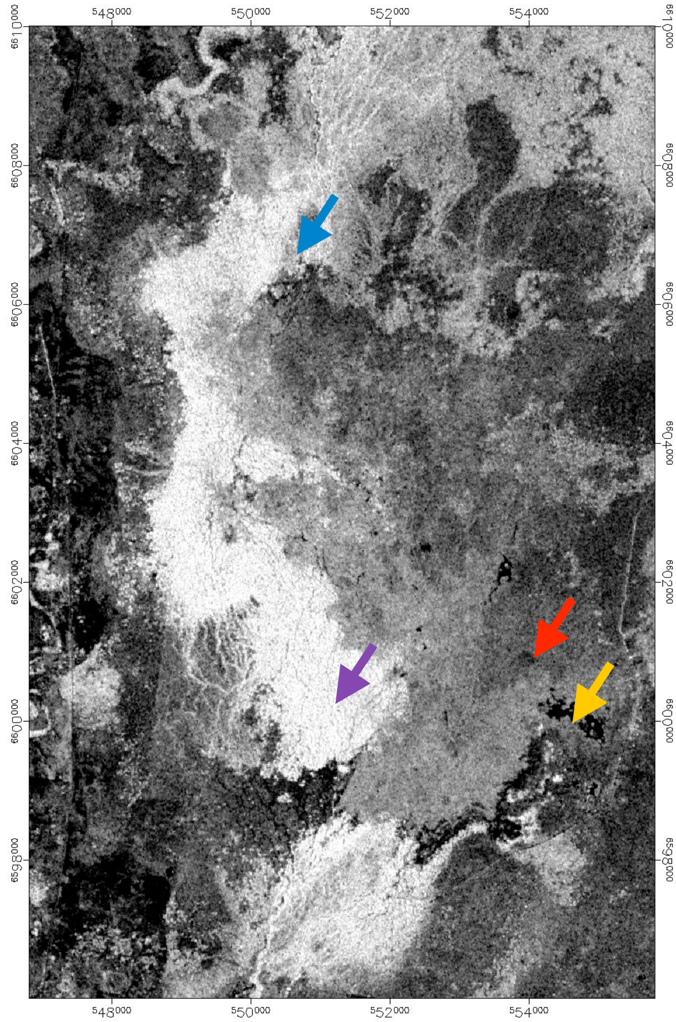

Figure 8 ALOS-PALSAR L-HH data over Area 1. The image was acquired on 21 January 2008 when the wetlands were at their wettest after a minor flood event © JAXA/METI

In Figure 9 a decorrelation stretch has been applied to highlight different surface conditions retrieved from a three-date multi-temporal dataset.

A decorrelation stretch provides a simple and effective method to remove high inter-band correlation and increase the range and diversity of colours in a colour composite image. The areas of flooded forest (yellow) have been masked from the image. There is good discrimination between open water (purple), edge wetland or marsh (red-magenta), inundated floodplain (green), other forest (pink) and surrounding wetland (blue).

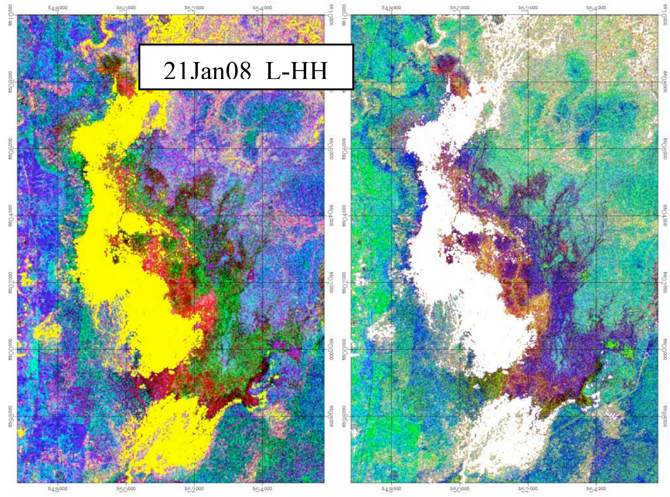

Figure 9. Decorrelation stretch of PALSAR bands Oct07 HH, Jan08 HH and Mar08 HH. Area 1, Northern Macquarie Marshes Nature Reserve. © JAXA/METI

A variety of advanced data-processing techniques are available to visually enhance and combine multiple dates of imagery for improved surface water detection. When applied to L-band PALSAR data, Independent Components Analysis (ICA) and Minimum Noise Fraction (MNF) provided good separation of flooded forests, open water, saturated soils and floodplain wetland. However, decorrelation stretching of the PALSAR dataset enhanced equally the visual detail and produced a colourful 3-band composite of the scene. Areas of open water, water with a cover of aquatic vegetation and wet soil were better discriminated in the decorrelation stretched image than in the ICA and MNF images.

Nevertheless all these techniques are effective in developing indices across dates when applied to stable calibrated data. Data acquired by ALOS PALSAR meet this criterion.

Multi-temporal PALSAR imagery can be interrogated and used to delineate wetlands, locate open water bodies, detect flooding beneath forest cover, identify flood extent and in this case, the area of the enlarged floodplain that was not flooded in January 2008.

The impact of temporary overbank flow from river channels and subsequent inundation of the heavily clayed floodplains is manifested on SAR imagery in different ways. Additional water leads to an increase in surface soil moisture and may also cause the water table to rise close to the surface. This soil moisture response can be observed at any wavelength by the increase in brightness or surface roughness caused by an increase in the dielectric and a flush in ephemeral vegetation growth. A vegetation flush is more easily confirmed in shorter wavelength data (e.g., C-band, ~5.3 cm; and X-band, ~2.5 cm), as a first surface return is received from diffuse scattering between small canopy components (leaves and stems).

End-member analysis using the Spectral Angle Mapper is a rapid classification technique that determines the L-band HH-polarimetric similarity of selected end-member spectra (average spectra from regions-of-interest representing selected surface types) to spectra of all pixels in the scene. It is essentially a physically based technique that determines the spectral similarity between two spectra by calculating the angle between them, treating them as vectors in space with dimensionality equal to the number of bands (3 dates). Smaller angles represent closer matches to the reference spectrum.

Areas that satisfy the criterion for 3 cover types, surface water, marshlands adjacent to the red-river gums, and floodplains subject to inundation, have been classified and are shown in Figure 9. Pixels further away than the specified threshold are not classified. The percentage cover of each class is also calculated (surface water 1.3%; marshland 4.3% and floodplain 7%). A median filter has been applied to suppress spuriously classified pixels. Forests and the immediate marshlands were flooded, but not part of the surrounding floodplain (blue in Figure 9).

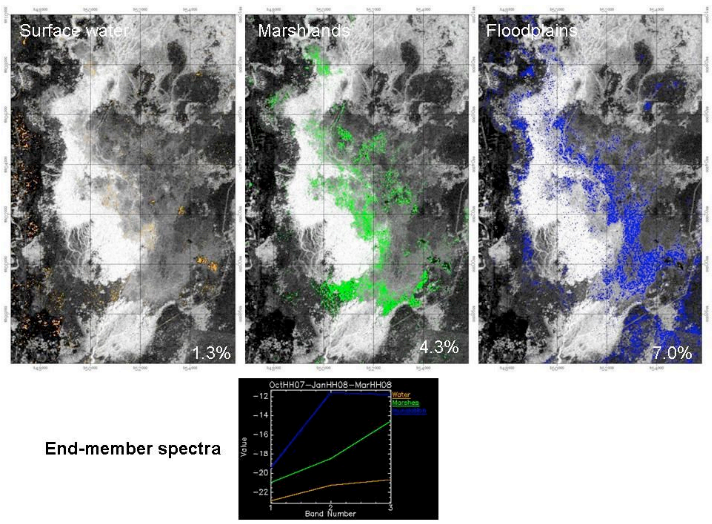

Figure 9 Spectral Angle Mapper (SAM) images based on PALSAR Oct.HH 07, Jan.HH 08 and Mar.HH 08 data of the Macquarie Marshes.
© JAXA/METI

Area 2 of the Macquarie Marshes is largely bare open ground covered with sedges and grasses which respond to flooding. Scattered trees and taller shrubs mark the watercourses. This effect is seen in Figure 10 where the areas displaying the highest component of change (+db) captured in the time-series, are covered with ephemeral vegetation underlain by soils with a high soil moisture content.

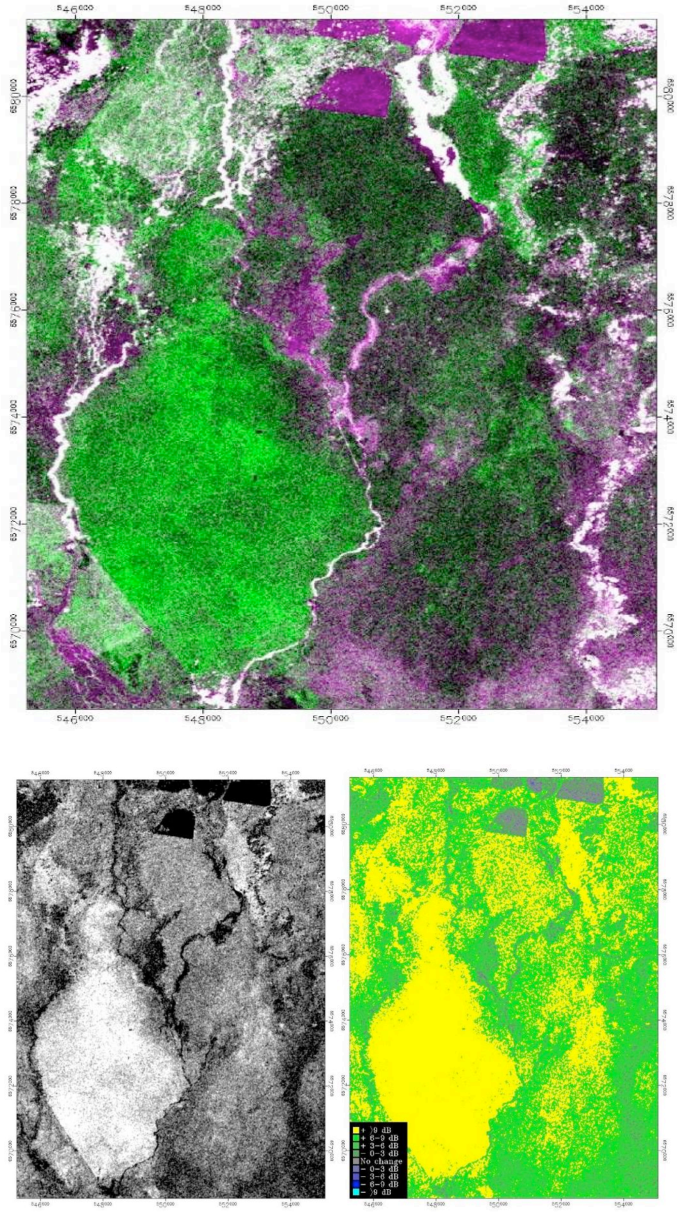

Figure 10. Area 2, Southern Macquarie Marshes Nature Reserve - colour composite and change detection images applied to HH-polarization PALSAR data acquired on 21Oct.07 and 21Jan08.
Top: R:G:B image of Oct07:Jan08:Oct07, respectively;
Bottom-left: Band difference - Jan08 minus Oct07; and
Bottom-right: Change detection, Oct07 to Jan08 – classes displayed in 3 dB increments for a +/- 9dB range. © JAXA/METI

The integration of multi-frequency SAR data in the form of PALSAR and TerraSAR-X can be shown to improve the discrimination of some wetland surfaces.

The TerraSAR-X StripMap data over Area 1 shown in Figure 11 was acquired on 2March 2008 and the PALSAR FBS data on 7March 2008. The TSX data provides a first return or largely a top of the canopy response, hence dark areas on the floodplain at X-band reveal areas where the water has flooded and overtopped the vegetation. Elsewhere there is a vegetation response from the sedges and low grasses that cover the remainder of the floodplain.

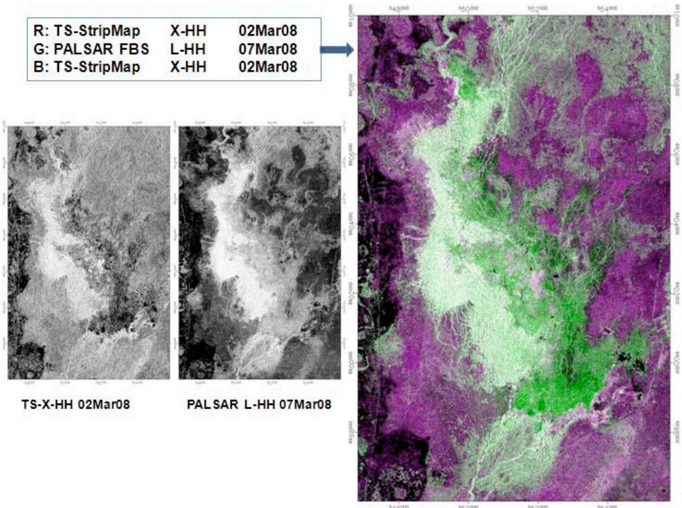

Figure 11. Integration of L-band PALSAR and X-band TerraSAR-X data for discrimination of wetlands. Area 1, Northern Macquarie Marshes Nature Reserve. ALOS K&C © JAXA/METI

An R:G:B colour composite image using bands TSX 2Mar08HH : PALSAR 7Mar08HH : TSX 2Mar08HH respectively, provides good discrimination of wetland surfaces. The backscatter over the floodplain wetland is dominated by the PALSAR Mar08 response (green on image). This is due largely to the L-band response to high soil moisture and roughness.

The backscatter over the surrounding floodplain area is dominated by the TXS Mar08 response (purple on image). The low shrubs and grasses of the floodplain provide many opportunities for volume scattering at X-band. Patches are observed in the edge wetland where the response is also dominated by the TSX Mar08 image. These are most likely areas of very high backscatter a result of ponded water with aquatic vegetation

In the PALSAR data, however, the full extent of the floodplain can be determined as flooded or not, since the longer wavelengths interact only with the woody component and not the shorter grasses.

The integration of near-coincident PALSAR and TerraSAR-X data revealed the extent of floodplain inundation and presence of aquatic vegetation in ponded areas. The PALSAR data were responsive to areas of high soil moisture and roughness, including flooded forest and wet soils. The dark areas on the floodplain at X-band reveal areas where the water had overtopped the vegetation in the wetlands. Scattered bright patches indicate high dielectric from soil moisture and or roughness from the surface of ponded water or water with aquatic vegetation.

Change detection applied to suitably calibrated SAR data reveals areas where a change in brightness has occurred in response to changes in wetland condition and provides a mechanism for understanding the hydrological and ecological changes occurring in an area. The integration of L-band PALSAR data and the shorter wavelength TerraSAR-X or Radarsat-1 data provides good opportunities for the further characterization of wetland extent and surface composition.

VI. CONCLUSIONS

This study which is ongoing demonstrates the ability of PALSAR to map and monitor changes in wetland hydrology and to discriminate between different wetland cover types.

In the Lower Mekong Basin flood mapping and determining wetland extent are clearly possible with PALSAR data. Detecting changes in the landscape response as water levels retreat can be deciphered from multi-temporal datasets. Registration and analysis of calibrated JERS-1 and PALSAR data allow scene changes over a longer period of time.

Following the release of environmental water into the Macquarie Marshes, and acquisition of a suitable short period time-series of L-band ALOS PALSAR data, the following outcomes were realized:

- The presence of and changes in surface water and soil moisture content;
- The generation of spatial map data of inundation extent over the period of image acquisition;
- The monitoring of flood extents and changing wetland dynamics over the time-frame of image acquisition;
- The discrimination of wetland cover classes using time-series analysis;
- Monitoring of changes in wetland condition using change detection techniques; and
- The generation of spatial map data of wetland community extent.

Additionally, the incorporation of multi-frequency SAR data (e.g., ALOS PALSAR and TerraSAR-X) may help achieve improved discrimination of wetland cover types based on shorter- or longer-wavelength radar response to vegetation structure, moisture content and surface roughness.

ACKNOWLEDGEMENTS

Special thanks to Dr. Anthea Mitchell from the School of Biological, Earth and Environmental Sciences at the University of New South Wales who was heavily involved in all studies related to the Macquarie Marshes.

This work has been undertaken within the framework of the JAXA Kyoto & Carbon Initiative. ALOS PALSAR data have been provided by JAXA EORC

REFERENCES

[1] Milne, A.K., Mitchell, A.L., Tapley, I.J. and Powell, M.J. 2007. Use of L-band radar to interpret inundation patterns in the Macquarie Marshes and Gwydir wetlands. Report submitted to the NSW Department of Environment and Climate Change (DECC), Sydney, November, 2007 pp77.

[2] Milne, A.K. and Tapley, I.J. 2004. Mapping and Assessment of Wetland Ecosystems in the Northwestern Tonle Sap Basin with AIRSAR Data, Results of a Pilot Study jointly Funded by the Mekong River Commission and the University of New South Wales, April 2004, pp129.

[3] Milne, A.K. and Tapley, I.J. 2007. Assessment of wetland ecosystems and change in the Tonle Sap Basin, Cambodia, using AIRSAR and JERS-1 radar data. *Asian Journal of Geoinformatics*, 7, 2: 21-29.

[4] Kingsford, R.T. and Thomas, R.J. 2001. Changing water regimes and wetland habitat on the Lower Murrumbidgee floodplain of the Murrumbidgee River in arid Australia. National Parks and Wildlife Service, Sydney.

[5] Milne, A.K and Mitchell, A.L. 2006. Remote sensing requirements of Riverbank: monitoring environmental water flows and their effects. Research report prepared for the Department of Environment and Conservation, Sydney, August 2006, pp99.

[6] Milne, A.K., Tapley, I.J., Mitchell, A.L., and Powell, M.J. 2008. 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 2008 pp280

Anthony Milne received his B.A degree in Geography from the University of New England, Armidale in 1967; Honours Masters in Geomorphology, University of Sydney in 1974 and a PhD from the University of Colorado, Boulder, in 1977.

He is currently a Visiting Professor of Geography and Remote Sensing in the School of Biological, Earth and Environmental Sciences at the University of New South Wales, Sydney, Australia and Remote Sensing Science Manager in the Australian Government sponsored Cooperative Research Centre for Spatial Information. He is also a Co-Director of Horizon Geoscience Consulting Pty. Ltd founded in 1992. His research interests lie in radar remote sensing, vegetation assessment and the mapping of wetlands.

Ian Tapley received his Ph.D in 1989 from the Curtin University of Technology in Perth. Formerly a Principal Research Scientist with CSIRO Australia, he is now a Co-Director of Horizon Geoscience Consulting based in Perth, Western Australia. His current interests lie in radar polarimetry and interferometry for landcover mapping, landform definition and change detection.