THE JOINT REMOTE SENSING RESEARCH PROGRAM





2012 - 2013 ANNUAL REPORT

The University Of Queensland AUSTRALIA

Queensland Government

NSW GOVERNMENT Office of Environment & Heritage

State Government Victoria Department of Environment and Primary Industries

TERN Terrestrial Ecosystem Research Network AusCover

STATE TO NATIONAL COLLABORATION

The Joint Remote Sensing Research program (JRSRP) was founded in 2007 and is a collaboration between the Biophysical Remote Sensing Group at the University of Queensland's Centre for Spatial Environmental Research, and remote sensing groups at the Queensland Department of Science, Information Technology, Innovation and the Arts (DSITIA), the New South Wales Office of Environment and Heritage (OEH) and the Victorian Department of Environment and Primary Industries (DEPI). The JRSRP also functions as the Terrestrial Ecosystem Research Network's (TERN) Auscover Brisbane Node. Our program incorporates skilled researchers, government scientists, environmental managers and significant computing and data storage capacity from within these agencies. Our principals of operating are to develop and implement scientifically sound approaches that contribute to national and international sciences, and are open and publicly accessible, for use in public good activities.

CONTENTS

THE JOINT REMOTE SENSING RESEARCH PROGRAM

The Joint Remote Sensing Research Program has developed new and improved methods, algorithms and tools for natural resource assessment and monitoring. We continuously incorporate new sources and types of data as they become available and we are committed to making our data and methods openly available, through data and process sharing initiatives, such as TERN and Google's Earth Engine.

We also provide crucial information to the space agencies in the U.S., Europe and Japan, who operate satellite imaging systems that provide our data, and to the global science communities who use the algorithms developed within our program.

Our program was founded to enhance the value and use of remote sensing or earth observation data by developing methods and data analysis systems with an emphasis on research and capacity building for ecosystem monitoring and management in Australia. Specifically, we ensure the highest quality science is used to build, implement and improve environmental management procedures for state governments.

Yours sincerely,

Professor Stuart Phinn
Joint Remote Sensing Research Program Director

The Joint Remote Sensing Research Program aims to increase Australia's capacity to conduct pure and applied research using satellite, airborne and field data sets to develop and implement effective environmental monitoring and management techniques, which are freely accessible, at local, state and national scales.

We collect and analyse field and remotely sensed data to develop, test and publish calibrated and validated maps and models of the biophysical properties and processes in Australian ecosystems. Remote sensing is the science of deriving information about the earth's ecosystems from data acquired at a distance. We manage substantial data sets covering most of the Australian east coast and a collection of unique field based remote sensing data for assessing the accuracy of the satellite image based maps. We also operate a significant set of internationally unique field calibration and validation equipment, including spectrometers, ceilometers/photometers, Leaf-Area-Index sensors and ground-based full waveform Lidar. These instruments can be deployed for use in terrestrial, marine and atmospheric environments.

Remotely sensed data from satellites and aircraft provide regularly updated data from local to continental scales, providing a unique multi-scale sampling tool for local to continental scale mapping, modelling, management and monitoring of the environment. Data collection and analysis is repeated at regular intervals to produce time-series maps and data to monitor how these ecosystems change over time. Time-series mapping enables regulatory, management and policy-making partners to monitor and assess the impact of management programs affecting our agricultural and industrial land use practices, and of natural disasters such as the recent devastating droughts, floods and cyclones.

We provide workshops, training and education materials to students at the University of Queensland, at environmental management and remote sensing conferences, and within local, national and federal environmental management and remote sensing research groups around Australia.

The applications for our research are varied; for example, we advise government agencies on land use practices and provide scientific evidence to government to support their compliance investigations on vegetation clearing activities. We also advise government agencies on impacts of weather patterns on our ecosystems and landscapes, and we monitor and evaluate natural resource impacts following natural disasters including the recent tropical cyclones Larry and Yasi.

Land use and land management practices have a profound impact on our natural resources, the environment and agricultural production. The availability of consistent and reliable spatial information on land uses and land cover change is critical for sustainable natural resource management.

In Queensland we monitor ground cover, tree clearing and bodies of water on an annual basis and at times more frequently and update detailed land use maps for priority regions. We support policy and planning priorities including: the Strategic Cropping Land Policy; Trigger, Protection and Management Areas; the Vegetation Management Act; the leasehold land renewal process (Delbessie Agreement); and the development of regional plans including identification and extent of cane growing and grazing areas as part of the Reef Protection Package regulatory framework.

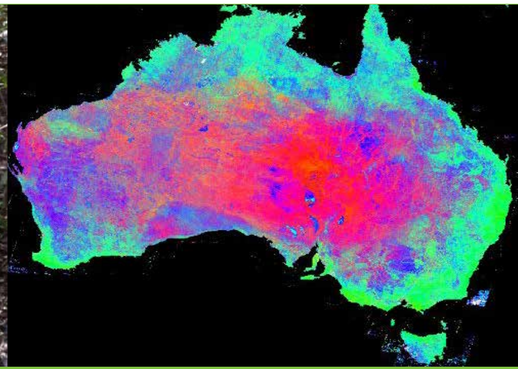
Our data and maps are used extensively by other state and federal government agencies, NRM regional groups, industry groups such as AgForce and increasingly by landholders. They are used for identifying priorities for investments and extension work, developing irrigation estimates in groundwater irrigation areas, and carbon stock assessment. They are used for monitoring biosecurity including identifying potential locations of Citrus Canker outbreaks and evaluating the risk of disease spread across banana plantations.

We invite you to explore more fully the research accomplishments and capabilities of the JRSRP by visiting our website www.gpem.uq.edu.au/jrsrp.

RESEARCH ACTIVITIES







Above: (left to right) SPOT5 satellite, fieldwork briefing, fieldwork measurements, plant canopy analysing, fractional cover output.

The Joint Remote Sensing Research Program's activities play a crucial role in assisting state government agencies and national resource management groups that are responsible for making environmental management decisions.

Engaging in evidence based decision making through employing a solid scientific approach leads to well informed policy decisions and effective environmental outcomes because decisions are based on accurate information. This, in turn, will lead to policies addressing the immediate and long term needs of our environment.

To provide such accurate results we use high quality science to assess, implement and improve spatial science procedures and standards in producing satellite image data that is used to map, quantify and monitor changes to our ecosystems. Our research results have been specifically used by state governments in the areas of:

- Vegetation management
- Catchment management
- Land use planning and practices
- Carbon stock assessment

OUR OBJECTIVES AT A GLANCE

- To provide the technical and human resources and knowledge to enable Australian government agencies to collect and use satellite and airborne image data in combination with field data, on a sustainable basis to produce accurate maps of Australian ecosystem properties that form the basis for their understanding and management.
- Continue to encourage partnerships and collaboration between private, government, non-government and academic sectors.
- Ensure all data and methods are subject to peer review and are publicly accessible.
- Increase awareness, coordination and the adoption of remote sensing technologies across local, state and commonwealth governments.
- Reduce costs for ongoing research and development by improved processes and reduction of duplication across state and national agencies.
- To provide the highest quality training to support current and future remote sensing and monitoring requirements to industry, private and government sectors.
- Attract new postgraduates to investigate new and streamlined applications and technology.
- Assist our staff to build professional careers through the support of current and future remote sensing and monitoring requirements.

BUILDING ROBUST MAPS & MODELS

The “mapping” process covered by JRSRP is extensive and provides an internationally unique approach to linking fundamental science through to evidence to be used for policy development and legal proceedings based on government legislation. The process starts by understanding how environmental properties, e.g. vegetation structure (height, biomass, % cover) and composition (e.g. species or communities) are able to be measured and mapped using airborne and satellite imaging systems. This requires extensive ground based measurements using JRSRP’s internationally unique set of field spectrometer, terrestrial laser scanners and other instruments to measure the environmental properties and determine how accurately and precisely they can be measured in airborne or satellite images. In the next stage algorithms are developed as computer code to transform images acquired from earth observation satellites to maps of vegetation structural or composition properties and extensive work is conducted checking these against field based measurements of the same features. These comparisons are used to refine the models and determine where they do and don’t work. Once the validated image mapping algorithms are established, the next stage is modifying them so they can be applied automatically across extensive satellite image archives that cover state and national areas, often every month and extending back almost 40 years in some cases. This enables small changes or corrections in the algorithms to be made and ALL of the archived data to be corrected at once and ready for use. This algorithm and image map development and validation is documented in a standardised on-line form with papers on the methods used subject to leading international journals for per review and to allow anyone around the world to use the methods for their own purposes. The processes of field and image data acquisition, storage, processing and distribution on state and nation-wide data are extensive and require significant investment in specialist infrastructure and skilled personnel for each stage. JRSRP enables state agencies to build these specialist resources, critically assess and grow them over time. As a result, the government agencies in JRSRP have an agile approach for tackling strategic challenges to any of their data acquisition, processing and delivery activities, by enabling their staff to establish a research to operational program to address the challenge. This has enabled JRSRP agencies to build on the substantive data collection, storage, analysis and sharing infrastructure and technical expertise that they have each built up over the past 20 years.

The majority of early work in JRSRP and its agencies focus on development of approaches to correct several types of satellite image data sets so they could be used for repeated large area and long term analyses, as the current operational satellites became un-useable or failed. This work has continued, focussing on radiometric, atmospheric, and terrain corrections which are now standardised, published in international peer reviewed literature and available as open-source code. Considerable effort is spent to develop, test, and document these approaches and to integrate them into an operational workflow that is able to process massive data volumes in a controlled, secure and repeatable manner. The approaches, software and systems development are recognised as world leading and provide guidance for national and international programs.

It is critical to note the role of the work that has been completed in JRSRP to date as underpinning the successful delivery of Australia’s new Terrestrial Ecosystem Research Network (www.tern.org.au) particularly is national remote sensing facility, Auscover (www.auscover.org.au/). The continental scale satellite products, field validation program, and overall structure of this activity would not have been possible if it were not able to build on the work JRSRP had already done in these areas, and to establish an open and collaborative working environment across agencies – which JRSRP is fundamentally based on. JRSRP continues to develop fundamental image geometric and radiometric correction routines and large area data processing capacities that have been adopted by Auscover. JRSRP’s focus on terrestrial laser scanning and SAR collection and processing has also been built into Auscover as a significant program.

KEY RESEARCH INITIATIVES

- Development of automated image-georegistration and radiometric correction software
- Full ingest of Landsat archive
- Calibration of airborne and satellite-based camera systems
- Development and assessment of Landsat sensor replacement options and procedures
- Development of fully corrected time series images
- Integration of field, LiDAR and imaging radar to map vegetation structure and biomass

COLLECTIVE RESEARCH

WHAT ARE THE BENEFITS?

Benefits for the JRSRP participants working collectively and being a part of the Joint Remote Sensing Research Program include:

- Cost effectiveness: the cost of research has been reduced through sharing, re-use and improvement as well as avoiding duplication of activities. Because programs participants' share common interests, research related activities and new products can be targeted based on what is relevant to the operational requirements of each organisation.
- Sharing of knowledge of industry and networking, how to find information,
- Access to new technologies and field instruments e.g. terrestrial laser scanner,
- Providing a single point of contact for other government agencies to engage and collaborate,
- Recognising activities provided by government and those provided by private industry,
- Producing assured high quality science through international peer review of models, collective field data and information sharing,
- Enabling education and skills progression for university students through JRSRP to operational activities, reducing a potential skills gap,
- The group has the combined capacity to address strategic problems common across agencies, e.g. loss of access to Landsat sensors and need for consistent national calibration and validation,
- Increased skills and capability within partner organisations.

HOW HAS THE JRSRP CONTRIBUTED TO REMOTE SENSING IN AUSTRALIA?

Queensland

45,000 Landsat Images of Queensland have now been processed to surface reflectance and fractional cover using the JRSRP algorithms. These are being used to develop tools and techniques to detect and map woody thickening and to support Strategic Cropping Lands tools for assessment officers and landholder.

The fractional cover product supports implementation and assessment of Reef policy, the Delbessie agreement (land –use monitoring), with data being directly delivered to landholders.

LIDAR processing tools support the calibration/validation of FPC which supports the vegetation management framework.

New South Wales

The JRSRP has enabled NSW remote sensing agencies to build on approaches developed in Queensland, and develop a system for SPOT data processing. This has provided a new capability for monitoring vegetation change, land use planning and exploring ecosystem function. It is estimated that JRSRP collaboration reduced the development cost by two thirds.

The implementation of the JRSRP software environment at AC3 has enabled OEH to analyse Landsat and SPOT imagery with a high level of automation. Without these systems the processing of imagery for vegetation change mapping would require several additional staff. The automated approach also provides better utilisation of IT assets hence reducing capital requirements. Software has been implemented so that there is a strong foundation substantially reducing development costs for new products.

Landsat fractional cover products that have been developed through the JRSRP are assisting catchment management authorities and regional groups with their strategic planning and operational programs. The products enable these groups to better targeting when investing funds for environmental projects.

The impact of research is totally dependent on the level of adoption of the research. The JRSRP has the necessary links to ensure that the research is implemented by the partners and standardised statewide and time series remote sensing products are produced and made available to users. The user's confidence in these products is further enhanced by calibration and validation programs leading to higher adoption.

National

Approaches have formed the basis of continental calibration and validation of image data sets and new continental biophysical products (fractional cover, persistent green, and biomass) that are available through TERN.

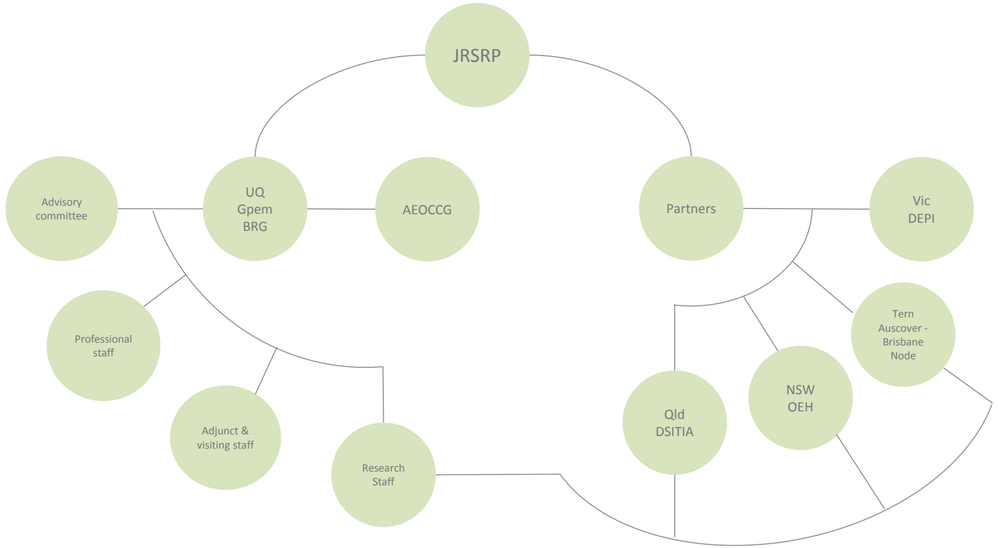
A focal point for developing a national coordination mechanism (Australian Earth Observation Coordination Group), national land cover mapping program and development and evaluation of the National Earth Observation Infrastructure Plan and draft National Space Policy.

International

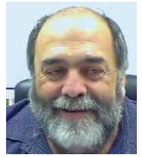
Engagement with Japanese Space Agency and Chinese Space Agency on development of products and calibration and validation.

STRUCTURE & GOVERNANCE

The JRSRP is managed and coordinated by the Biophysical Remote Sensing Group (BRG) in the School of Geography, Planning and Environmental Managment at the University of Queensland. Specific research activities are delivered through the programs partner facilities. Governance is managed via the Advisory Committee which has primary responsibility for the overall strategic direction, management and performance of the Joint Remote Sensing Research Program.



ADVISORY COMMITTEE



Ken Brook
Director of Land and Vegetation Science
Qld Dept Science, Information Technology, Innovation and the Arts

Christian Witte
Manager, Remote Sensing Centre
Qld Dept Science, Information Technology, Innovation and the Arts

Peter Scarth
Principal Research Scientist
Remote Sensing Centre
Qld Dept Science, Information Technology, Innovation and the Arts

Jeremy Black
Director, Native Vegetation Information, Science Division
NSW Office of Environment and Heritage

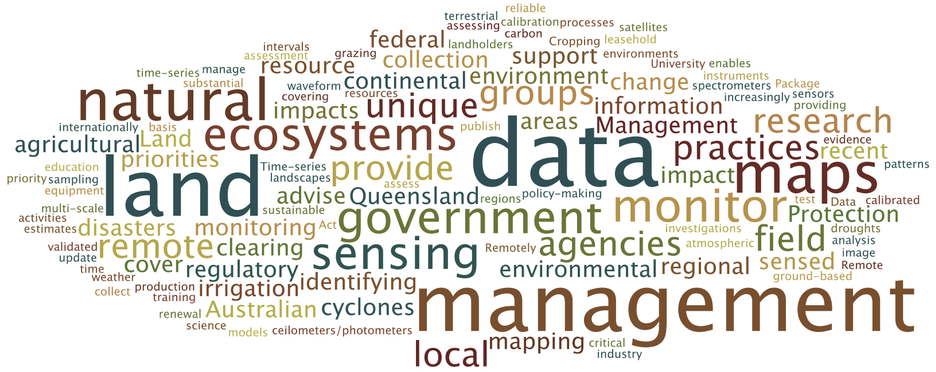
Richard Hicks
Manager, Remote Sensing & Land Assessment
NSW Office of Environment and Heritage

Tim Danaher
Manager of Remote Sensing Unit
NSW Office of Environment and Heritage

Andrew Mellor
Senior Project Officer
Remote Sensing
Vic Dept of Environment & Primary Industries

Jamie Shulmeister
Head of School
School of Geography, Planning & Environmental Management
University of Queensland

Stuart Phinn
Director Centre for Spatial Environmental Research
Director Joint Remote Sensing Research Program
Associate Sc+ience Director, TERN
School of Geography, Planning & Environmental Management
University of Queensland



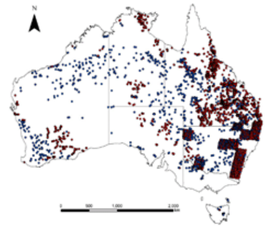
MAP • MODEL • MONITOR • MANAGE

RESEARCH TO SOLUTIONS

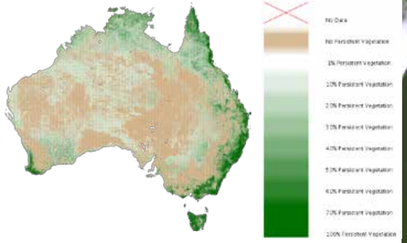
QUEENSLAND PERSISTENT GREEN VEGETATION FRACTION

The persistent green vegetation fraction product provides an estimate of the vertically projected green vegetation fraction where vegetation is deemed to persist over time.

The persistent green fraction product has been developed over the past year from our Landsat archive and extensive field data and is one of the key Queensland node AusCover deliverables. The product itself is based on a time series of fractional covered data which is processed based on the United States Geological Survey (USGS) Landsat Data.



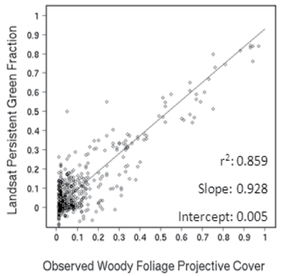
State vegetation cover cover sites used for national persistent green product.



National persistent green product.

VALIDATION

- Contingency tables used to derive accuracy statistics for persistent/not persistent classification
- Persistent green fraction estimates compared to field-observed woody foliage cover measurements (star transects)
- Further validation with Lidar-derived fractions forthcoming



MAKING DATA PUBLICLY AVAILABLE

This product required a large degree of collaboration between scientists across state and commonwealth organisations. The first step in the creation of the program was the selection and download of appropriate Landsat scenes. To do this it was necessary to find scenes that were both cloud free and also as dry as possible, preferably on anniversary dates over the 2000 - 2011 period that the US archive is available within Australia.

This was complete by first downloading the USGS database of all available scenes and then intersecting these with an analysis of the SILO rainfall surfaces across Australia which had been pre-processed to estimate the previous 30 day rainfall.

An additional step was to check the cloud masking flag which had been provided by the USGS. This enabled the correlation of over 4,500 images across Australia which was the most cloud free and dry. The list of downloadable scenes has been sent to the University of Queensland where they were downloaded using the AARnet connection and the scenes have been brought back up to DSITA and imported into the processing stream.

One of the initial issues was the large amount of cloud that was encountered across these scenes in Australia. Since the time frame and budget for development of the product did not allow for any manual processing, a fully automatic cloud mask had to be developed and this was based on an existing published cloud masking model with some local tweaks to improve its performance out in some of the bright areas of Australia. Once the cloud masking, cloud shadow masking, water masking and terrain masking were completed the images were then processed into fractional cover. The fractional cover model draws upon field data collected not only within Queensland but also within New South Wales, Victoria, the Northern Territory, South Australia and Western Australia.

The field data collection for the fractional cover product is being taken in collaboration with the Australian Bureau of Agricultural and Resource Economics (ABARES) who have supplied funding and training to the state and territory agencies to collect consistent national ground coverage data. This means that the fractional coverage product contains field data from across Australia and thus provides a better indication of ground coverage than earlier products that were based entirely on Queensland field sites. Fractional cover image processing is somewhat time consuming, with the original code taking up to 2 hours per image to process. After refining the algorithm it now only takes 15 minutes per image to process and so it was easy to process the entire archive into fractional cover. All of the images and processing scripts for this product are tracked through a separate database table which allows the efficient querying and extraction of data associated with this project.

A large amount of time was spent talking with various state and national agencies to attempt to acquire a calibration and validation data set for the existing green product. This included two primary sets of data, first a large and distributed set of field sites which were classified either as Woody or non Woody allowed the development of a decision tree model which took the annual time series of fractional cover and partitioned that into sites that were persistently green and sites that were perennially green. A second field data source is the amount of over story foliage projective cover for green vegetation. This allowed the calibration of sites that were deemed to be persistent into a biophysical variable representing the amount of green foliage as a percentage. The high performance computing systems at DSITA were used to test various time series models to provide estimates of the existing green fraction and this was made much easier by the large amount of field data that had been provided by various state and territory partners.

The final product used as a decision tree model to classify pixels as persistent green or not persistent green and then estimate the fractional cover for each pixel which is classified as persistent green using a robust aggression model. The product has an overall accuracy of 82.6%. An initial accuracy assessment of the persistent green vegetation fraction was produced by comparison to field measured woody foliage projected cover. A linear aggression analysis shows an R2 of 0.859 with a slope of 0.928 and an intercept of 0.005. Further validation based on the JRSRP Lidar processing task output which aims to develop better tools for extracting fractional cover from waveform Lidar data is planned over the coming months and this will allow the processing and analysis of large amounts of waveform Lidar data collected across the Northern Territory.

The process has produced a large amount of public available data and the layers include surface reflectance products, various masks for the data sets, time series masks of water within the landscape, fractional cover annually from 2000 and the existing green vegetation product which is available both as a national mosaic and as individual Landsat tiles. The data is now publicly available and has been transferred to the University of Queensland AusCover node and is available through the TERN network.

NEW SOUTH WALES SPOT 5 VEGETATION MAPPING & MONITORING

Remote sensing is used by the Office of Environment and Heritage for mapping and monitoring the extent of woody vegetation in the State of New South Wales. In the past OEH has relied solely on Landsat imagery to provide for these requirements but the need to map woody vegetation change in landscapes such as open woodlands with scattered trees, grasslands, and highly modified areas, has demanded the use of higher resolution imagery. The move to higher resolution SPOT 5 imagery has required the development of new methods for analysis of these images. The research has been done through the JRSRP as series of related research tasks that have provided the necessary image analysis tools for mapping woody vegetation change from SPOT imagery.

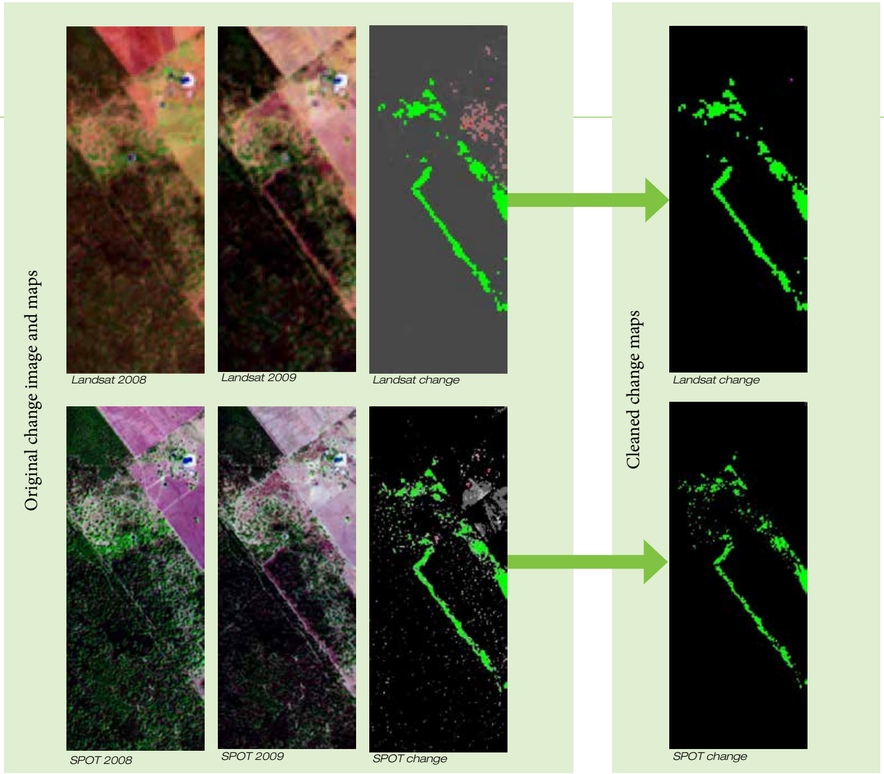
Firstly a method for radiometric correction of SPOT images to create standardised surface reflectance products was needed. This method is similar to the Landsat method but copes with the wider range of view angles possible with the SPOT sensor.

In order to make best use of the higher resolution provided by SPOT, a method for pan-merging the multispectral and panchromatic bands to create 5m resolution products was required. This method is unique as it provides increased resolution without distorting the spectral characteristics of the standardised reflectance products.

Other research tasks have resulted in SPOT Foliage Projective Cover (FPC) products based on cross-calibration with Landsat products, development of a woody vegetation change index for mapping woody vegetation change, methods for mapping surface water and masking cloud and cloud shadow. All these methods along with the standardised reflectance method are implemented as part of an image analysis toolkit which automatically generates these products as new SPOT images are acquired and loaded,

This series SPOT research tasks has resulted in a robust method for SPOT to SPOT change at 5m resolution which is being used to map annual woody vegetation change from 2008–2012.

These methods and products provide a platform for the development of a 5m resolution statewide woody extent and FPC map over New South Wales using multi-date SPOT images.

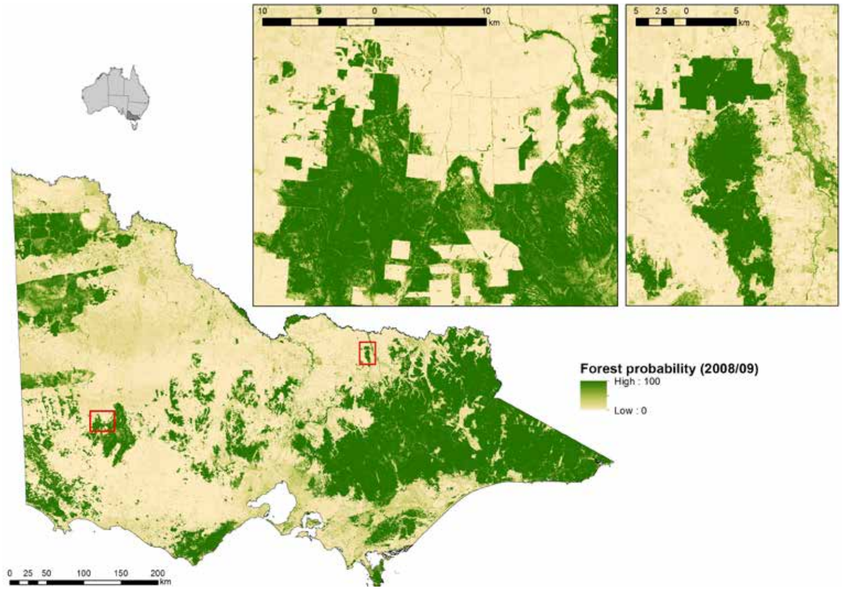


EXAMPLE PRODUCTS

FOREST MONITORING IN VICTORIA

The Victoria Department of Environment and Primary Industries (DEPI) has utilised JRSRP IT image processing infrastructure to implement JRSRP remote sensing image standardisation techniques for undertaking state-wide forest monitoring and reporting. Image standardisation techniques – which remove between scene variations in brightness due to sun position differences, topography and atmospheric conditions – allow DEPI to produce state-wide accurate and consistent forest extent, cover and classification maps.

Through the JRSRP, with a time-series of standardised Landsat satellite imagery and change detection algorithms, DEPI are further developing their forest monitoring capabilities by quantifying disturbance and measuring trends in public native forests condition over the past 20 years.



INFORMED LAND MANAGEMENT DECISIONS

With the support of the JRSRP and in collaboration with CSIRO, The Royal Melbourne Institue of Technology (RMIT) and the Cooperative Research Centre for Spatial Information (CRC SI), DEPI Victoria has set up three 25km2 permanent research sites in central and eastern Victorian forests. The sites are being used to conduct research into remote sensing forest characterisation.

Project partners have conducted fieldwork to collect structural and functional measurements of vegetation, using traditional forest mensuration transects and plots, terrestrial LiDAR scanning and high temporal resolution in-situ autonomous laser scanners and dendrometers.

This project demonstrates the benefits of co-investment in data infrastructure and acquisition to support collaborative research efforts and ultimately inform policy and land management decision making across these important ecosystems.

FIELDWORK • SCIENCE • MANAGEMENT

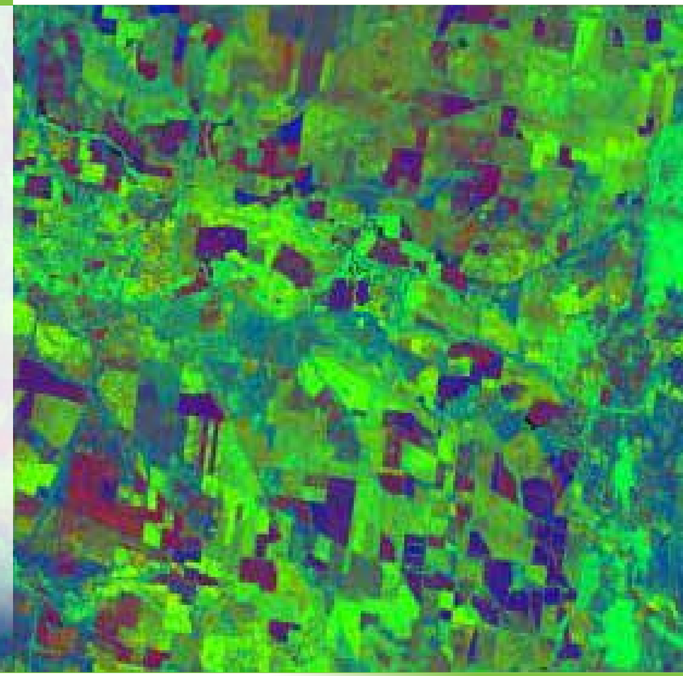
RESEARCH ACTIVITIES

GROUND COVER & FRACTIONAL COVER

A new approach has been developed for mapping the vegetation cover into its component parts of green, non-green and bare ground using the Landsat archive. This information is based on extensive field data collected across multiple state and national programs, including Auscover, and uses a sub-pixel approach to tease out the 'fractions' of green, non-green and bare ground which make up the reflectance signal measured by the satellite. The output product, termed 'fractional cover', is being used for a wide range of operational outcomes including grazing lands management, monitoring and reporting on the health of the Great Barrier Reef, and for estimating fuel loads in bushfire hazard mapping.

Additional research is developing innovative ways to use these data to represent landscape changes and assist policy-makers and land managers to implement improved land management, particularly in the grazing industry. This includes using compositing approaches to develop seasonal vegetation cover products and applying spatial statistical approaches to represent the dynamics of the vegetation cover for highlighting areas of consistently high and low cover, seasonal responses, and longer-term processes such as woodland thickening.

The algorithm for fractional cover information is also being modified for use in Google's Earth Engine, which will enable the entire Landsat and MODIS archive, containing images from all over the world, on a weekly basis to 2001 (MODIS) and every 16 days 1972 (Landsat). When complete this will be a significant step change in our remote sensing capabilities, with verified algorithms able to be applied through web-browsers to global peta-byte scale archives, and deliver products for direct use. This enables algorithms, data and products to be accessible to anyone with a suitable web-browser.



STANDARDISED SURFACE REFLECTANCE

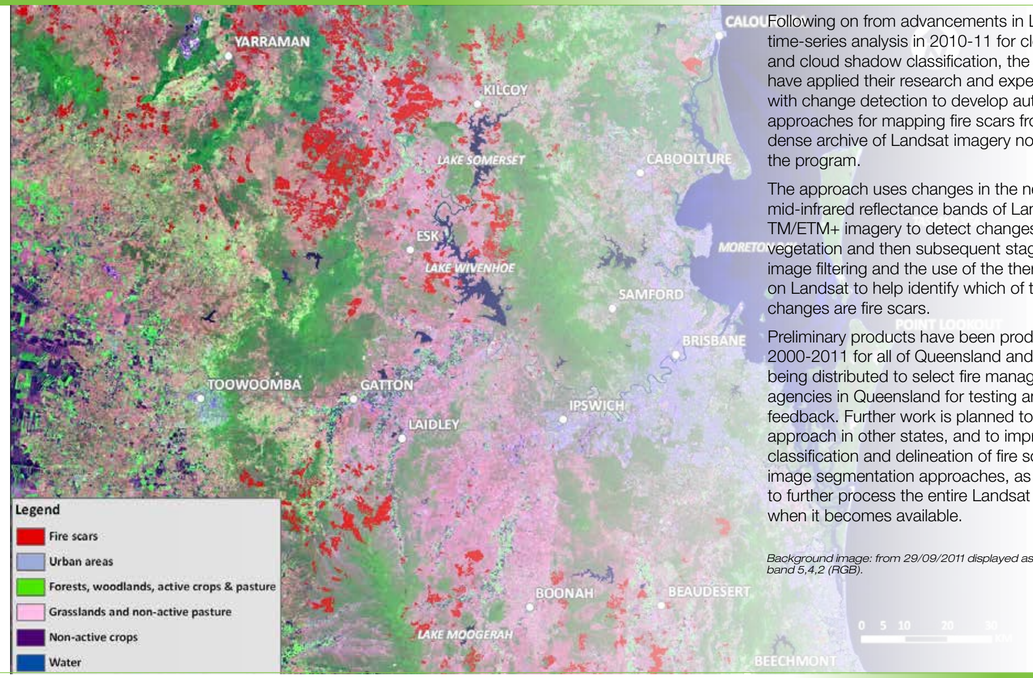
When using remote sensing for operational mapping and monitoring of vegetation it is desirable to remove effects that reduce the accuracy of results. There is variation due to the images being acquired at different times with different sun angles and different atmospheric conditions. The topography and satellite viewing angle also combine to create shadows that vary over the seasons.

The correction method has been the results of many years of research by the JRSRP partners. It was designed to work with Landsat and SPOT imagery but can be adapted to other types of medium resolution imagery.

This research has been implemented operationally and has been used to process some 45000 Landsat 5 and 7 images and 2,500 SPOT 5 images over Queensland, New South Wales and Victoria for use in mapping and monitoring programs. It will also be used as the basis when developing maps of other biophysical variables.

Flood, N.; Danaher, T.; Gill, T.; Gillingham, S. (2013) An Operational Scheme for Deriving Standardised Surface Reflectance from Landsat TM/ETM+ and SPOT HRG Imagery for Eastern Australia. *Remote Sensing*, 5, 83-109

FIRE SCAR MAPPING



Following on from advancements in Landsat time-series analysis in 2010-11 for cloud and cloud shadow classification, the JRSRP have applied their research and experience with change detection to develop automated approaches for mapping fire scars from the dense archive of Landsat imagery now held by the program.

The approach uses changes in the near- and mid-infrared reflectance bands of Landsat TM/ETM+ imagery to detect changes in vegetation and then subsequent stages apply image filtering and the use of the thermal band on Landsat to help identify which of those changes are fire scars.

Preliminary products have been produced for 2000-2011 for all of Queensland and these are being distributed to select fire management agencies in Queensland for testing and feedback. Further work is planned to test the approach in other states, and to improve the classification and delineation of fire scars using image segmentation approaches, as well as to further process the entire Landsat 5 archive when it becomes available.

Background image: from 29/09/2011 displayed as Landsat TM band 5,4,2 (RGB).

TERRESTRIAL LASER SCANNER

Remote sensing is used by the NSW Office of Environment and Heritage for mapping and monitoring the extent of woody vegetation in the State of New South Wales. In the past OEH has relied solely on Landsat imagery to provide for these requirements but the need to map woody vegetation change in landscapes such as open woodlands with scattered trees, grasslands, and highly modified areas, has demanded the use of higher resolution imagery. The move to higher resolution SPOT 5 imagery has required the development of new methods for analysis of these images. The research has been done through the JRSRP as series of related research tasks that have provided the necessary image analysis tools for mapping woody vegetation change from SPOT imagery.

Firstly a method for radiometric correction of SPOT images to create standardised surface reflectance products was needed. This method is similar to the Landsat method but copes with the wider range of view angles possible with the SPOT sensor.

In order to make best use of the higher resolution provided by SPOT, a method for pan-merging the multispectral and panchromatic bands to create 5m resolution products was required. This method is unique as it provides increased resolution without distorting the spectral characteristics of the standardised reflectance products.

Other research tasks have resulted in SPOT Foliage Projective Cover (FPC) products based on cross-calibration with Landsat products, development of a woody vegetation change index for mapping woody vegetation change, methods for mapping surface water and masking cloud and cloud shadow. All these methods along with the standardised reflectance method are implemented as part of an image analysis toolkit which automatically generates these products as new SPOT images are acquired and loaded,

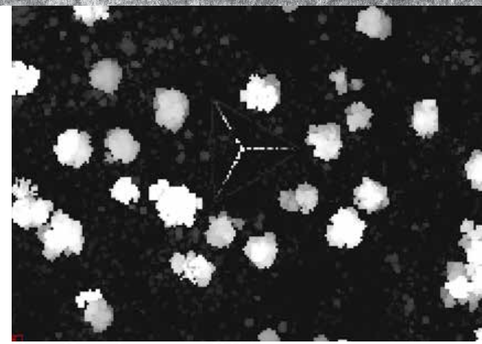
This series SPOT research tasks has resulted in a robust method for SPOT to SPOT change at 5m resolution which is being used to map annual woody vegetation change from 2008–2012.

These methods and products provide a platform for the development of a 5m resolution statewide woody extent and FPC map over New South Wales using multi-date SPOT images.

LIDAR DATA PROCESSING

Processing of remotely sensed imagery to standard products is now performed routinely by the JRSRP partners. Methods for routine processing of airborne Lidar (light detection and ranging) data over large areas are subject to ongoing development in processing software, such as the open source Sorted Pulse Data Library (SPDLib; http://www.spdlib.org). This library, and a growing suite of dependent software, is allowing standard image products to be produced from discrete return and waveform Lidar on both airborne and terrestrial platforms.

The JRSRP has also been collecting the many existing airborne Lidar surveys that have been acquired over NSW, but which have not been used for environmental mapping and monitoring. These datasets, along with substantial Queensland, Victorian, and TERN Auscover Lidar archives, provide a crucial link between field and satellite data, and will facilitate the calibration and validation of future satellite image products. Improved methods for biophsyical parameter retrieval from waveform Lidar have also been developed, leading to wider application of this relatively recent airborne Lidar technology for environmental mapping and monitoring.



(Top image) raw and processed airborne Lidar images. (Right iamge) Airborne Lidar image, height range 0–37 m, flux tower is 37 m tall, trees are between 10 m – 22 m. 220 m across.

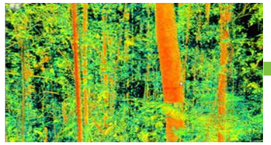
TERN AUSCOVER - BRISBANE NODE

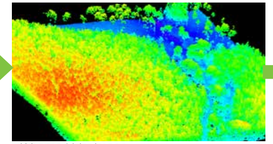
Auscover field sites

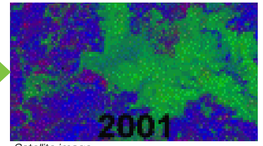

Terrestrial laser scanner data capture


Airborne Lidar data capture


Satellite data capture


Terrestrial laser scanner data output


Airborne Lidar image



Satellite image

The AusCover facility within Australia's Terrestrial Ecosystem Research Network (TERN) provides a national expert network and a data delivery service for Australian biophysical remote sensing data time-series. Staff from the JRSRP forms the Brisbane node of the Auscover facility within TERN.

The aim of AusCover is to provide a nationally consistent approach to deliver and calibrate past, current and future satellite image based datasets and produce ecosystem science data products designed for Australian conditions.

The physical implementation of the AusCover Data facility provides standardised, calibrated and validated biophysical data products, delivered via a 24/7 Distributed Data Archive and Access Capability (DAAC) linked to the AusCover Portal http://data.auscover.org.au/xwiki/bin/view/Product+pages/WebHome.

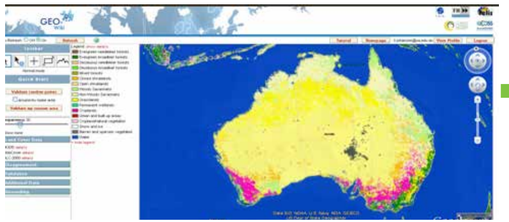
The DAAC comprises several regional nodes, one of those being Brisbane, with a central console located in Canberra, acting as the AusCover portal to TERN. A large number of continental-scale time series products and associated metadata are available on the portal. All field and airborne data collected, and associated metadata, can be freely downloaded from the AusCover data servers. This occurs through either the AusCover Visualisation Portal (http://data.auscover.org.au/Portal2/) or via the products' metadata records.

The portal is available for research and other commercial and non-commercial applications and all data are publicly accessible and retrievable.

QUESTIONS THAT CAN BE ADDRESSED THROUGH THE USE OF AUSCOVER INFORMATION:

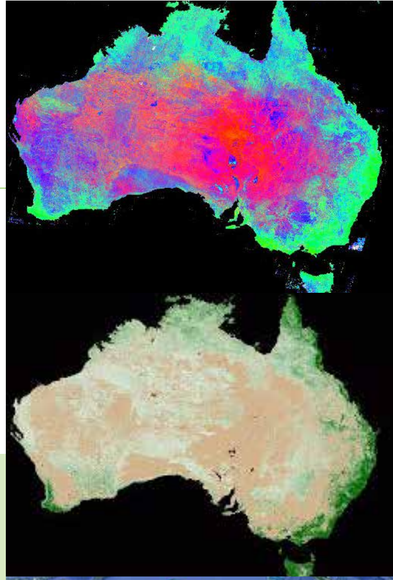
- How, in space and time, have key environmental variables changed over the period of satellite image archives for Australia?
- Can we measure at regional scales the relative benefits/impacts of legislated environmental management programs on Australia's major land and coastal ecosystems?
- How accurate are each of the AusCover data sets, and what image and ground-based measurements are necessary to enable them to be used to assess natural and human induced changes or management actions in the environment?

AUSCOVER
RESEARCH HIGHLIGHTS



Left: Auscover is collaborating with the Geo-Wiki project in Europe, to provide an online and mobile means to test and validate mapes of land-cover and biophysical variables produced by TERN and it's partners.

Right: (from top to bottom) Fractional cover output, national persistent green product, Auscover field sites.



The Brisbane Auscover node, covering Queensland and New South Wales is run by Dr Kasper Johansen, the science coordinator, with assistance from the Joint Remote Sensing Research Program staff in the Queensland and New South Wales Governments (R. Trevithick, P. Scarth, J. Armston, C. Witte, T. Danaher and T. Gill) and from S. Phinn.

Research

- Field and airborne LiDAR and hyper-spectral data collection campaigns were undertaken at several locations across Australia, including Chowilla (SA), Rushworth Forest (VIC), Whroo Flux tower site (VIC), Watts Creek (VIC), Zig Zag Creek (VIC), Credo (WA), and Robson Creek (QLD), with the South East Queensland and Litchfield National Park (NT) sites planned for January and May 2013, respectively.
- A national time-series of Landsat-5 TM and Landsat-7 ETM+ based Fractional Cover was produced as part of the process to produce the Persistent Green Vegetation Fraction (PVG) product, which was completed at the end of 2012. The PGV product can be accessed and freely downloaded from http://data.auscover.org.au/xwiki/bin/view/Product+pages/Persistent+Green-Vegetation+Fraction.
- Landsat based time-series of 15 AusCover focus sites (1400 images), including production of (1) reflectance; (2) water mask; (3) fractional ground cover; (4) FPC; and (5) NDVI has been completed.
- Work was initiated on the AusCover Geo-wiki branch in collaboration with the Austrian based International Institute for Applied Systems Analysis. The online Geo-wiki will enable anyone to contribute their local knowledge to the development and validation of Australian land-cover maps. Validation information can be submitted from visual assessment of Google Earth as a backdrop or by uploading field photos taking from a smartphone and submitted via the developed Geo-wiki app. The expected release of the AusCover Geo-wiki branch is May 2013.
- A workshop was held at DSITIA to showcase AusCover products and demonstrate to users how to access and download the data sets and to receive feedback from users to improve current data accessibility procedures.
- Field equipment, including the Riegl VZ400 Terrestrial Laser Scanner and associated software were purchased jointly by the AusCover Brisbane node and DSITIA. An additional LiCor LAI-2200 wand has also been purchased to enable simultaneous above and below canopy measurements of incoming light to estimate Leaf Area Index.
- Production of standardized field data collection protocols and metadata and processing and storing procedures for all field data.

Planned Auscover Research Activities

The research plan for AusCover over the next year are extensive and varied. Some of the Brisbane node's planned activities include:

- New field and airborne campaigns in South East Queensland and Litchfield National Park.
- Further validation of the Persistent Green Vegetation Fraction product using an extensive number of LiDAR data sets across Australia.
- Production of Open Data Kit (ODK) forms to be used for field data collection using smartphones and tablets.
- Quality Assurance and Quality Control of all collected airborne LiDAR and hyper-spectral data sets

INDUSTRY ENGAGEMENT

ROAMES - Remote Observation Automated Modelling Economic Simulation – comprises specially modified aircraft fitted with sensors that include photographic and LiDAR distance measurement equipment. The sensors capture large volumes of data which are processed to enable reliable and precise measurement of Ergon Energy's electricity network and surrounding objects such as buildings, terrain and vegetation.

Collaboration has been initiated between JRSRP participants and the ROAMES Group, and there is considerable interest in research into leaf area index retrieval, biomass monitoring, ground base mapping, and the detection and analysis of gullies within the landscape, including monitoring the change gullies over time.

ROAMES will capture 1.1 terabytes of data per hour of mission which will compress down to around 40 gigabytes. So annually, the system will capture approximately 20 terabytes of compressed data. The data itself will be stored on the QCIF (The Queensland Cyber Infrastructure Foundation) Cloud, and there are talks under way as to how to best manage, store, access and license the data itself. This data will also require the development of new processing tools, processing management and delivering mechanisms for the Lidar data itself.

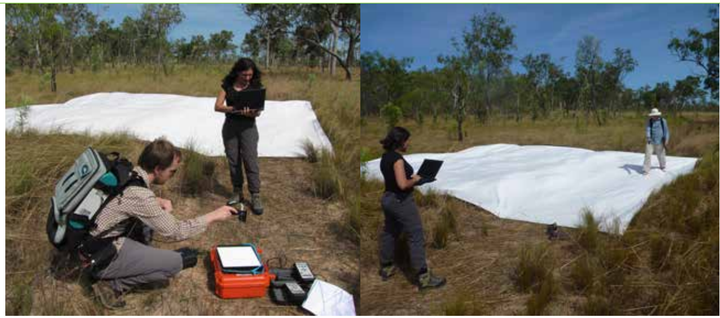
There is a wide range of applications of these data sets including the analysis of built infrastructure, the analysis of vegetation and landscape, state and change; and this will be assisted by the building of open standards, software and processes.

ROAMES

CALIBRATION & VALIDATION

This project is currently in the development stage and the key questions that will be answered by this research are:

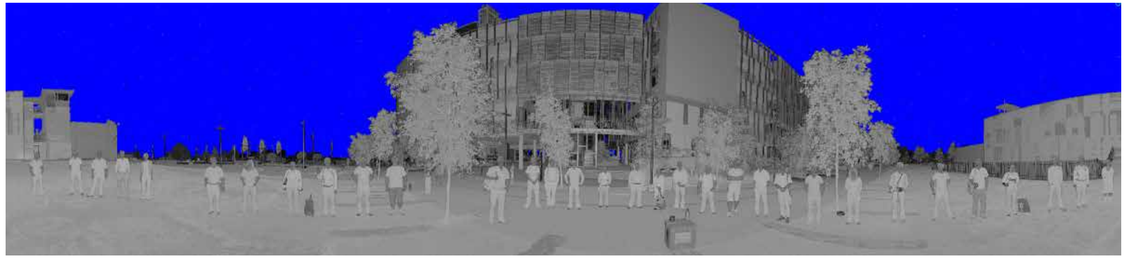
- The development of a process to use the ROAMES as a sampling tool for calibration and validation of regional and state wide mapping and monitoring activities, including gullies, vegetation [persistent green, foliage cover, leaf area index, above ground biomass, thickening, re-growth and riparian areas; and also to satisfy field calibration and validation requirements.
- Development and optimization of an open processing stream to derive key bio-physical attributes using the ROAMES data and instrument configurations. This includes the analysis and development of tools to handle full waveform and discreet return Lidar data, and the analysis of the effect of sensor and survey configurations on the environmental retrievals.
- It also links well with the CRC-SI (Cooperative Research Centres for spatial information) Program 3 (Spatial Data Infrastructure Research Engagement Workshop); particularly for "big spatial data" questions. These include processes and research around the collection, storage, discovery, processing, licensing and accessibility of large spatial data sets.
- Finally, linking of all of this to environmental monitoring systems and programs by the state and national are an essential part of the project proposal. The JRSRP obviously has a number of research tasks, which directly address parts of this proposal, and will continue to have ongoing involvement with these industry partners.



Above: (left to right) Field spectrometer callibration, validating callibration target for airborne data capture.

Below: Field data validation.

CONFERENCES, WORKSHOPS & TRAINING



Above: Terrestrial laser scan of unconference participants, picture by John Armston and Peter Scarth.

#RSGIS QLD UNCONFERENCE

On the 21st March, 2013 the first annual Remote Sensing and GIS Unconference was hosted at the Queensland Ecosciences Precinct.

This is a a participant-driven whole day event where everyone attending is encouraged to participate, by either giving a quick presentation of their work or ideas in one of the sessions, and/or by running/attending one of the workshop sessions. Wikipedia describes an unconference: "An unconference is a participant-driven meeting. The term "unconference" has been applied, or self-applied, to a wide range of gatherings that try to avoid one or more aspects of a conventional conference, such as high fees, sponsored presentations, and top-down organization."

This event was an initiative of Peter Scarth of the Remote Sensing Centre at the Queensland Governments Department of Science, Information Technology, Innovation and the arts, and organised by the Joint Remote Sensing Research Program.

This event showcased many of the cutting edge spatial research projects that are happening locally within the Government, Universities and Industry. Held as a Barcamp type event, the content is user driven with a mix of lightning talks around specific sessions with specialised participant driven workshops on particular topics of interest to you, such as Terrestrial Laser Scanner applications, Big Data services and delivery and/or Open Source GIS.

This event was a great success and received by a full house! Lets hope this is the first of many.

AUSTRALIAN EARTH OBSERVATION COMMUNITY COORDINATION GROUP

The Australian Earth Observation Community Coordination Group (AEOCCG) is a collective group that provides a coordinating and sharing point for all people using images collected from satellite, airborne or any other platform (Earth Observation, EO) for any purpose in Australia. The group was formally launched in launched in March 2013 via it's website **www.aeoccg.org.au**.

The group cover's research, private industry, government, education and non-government activities. And, this covers people working across all natural and built environments, spanning, the earth's atmosphere, terrestrial, aquatic, urban and marine environments.

The AEOCCG has been formed to enable all of the people who collect and use earth observation data to have a forum to present and discuss their activities and define their needs for support from industry, academia and government. It is meant to span all disciplines and provide an inclusive and collaborative resource to improve access to and use of earth observation data for Australia and operates external to government agencies at any level in Australia.

The AEOCCG aims to provide a national forum for regular communication and coordination of earth observation data collection, distribution and validation across all relevant federal and state government agencies, research agencies, universities, private sector and non-government organisations.

The AEOCCG is formally housed and supported by The Joint Remote Sensing Research Program, with the support of Remote Sensing and Photogrammetry Commission of SSSI of Australia. With funding contributions from the following organisations:

- Gesoscience Australia
- CSIRO
- Remote Sensing and Photogrammetry Commission of SSSI
- The Joint Remote Sensing Research Program

Goals

- the range of activities in Australia that are using earth observation data,
- the requirements for improving earth observation data collection and sharing,
- the requirements for improving earth observation data analysis, and
- to report the findings of meetings to the Australian Government Earth Observation from Space Working Group (AGEOSWG).

Group Activities

The group meet's several times a year using open–space technology approaches and in a virtual setting to enable as many people as possible to participate for minimal cost.

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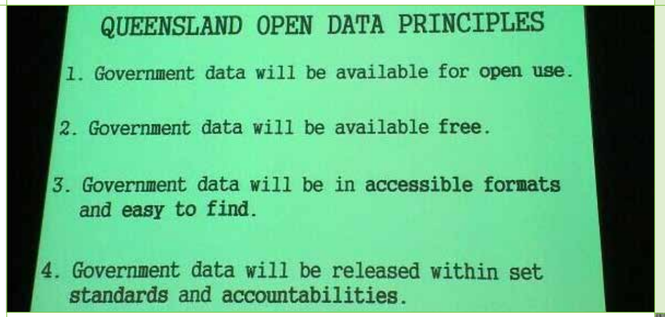


Above: Open data presentation at #RSGIS Unconference, March 2013.

- AEOCCG's first All of Community Meeting, via Webinar, April 2013.
- #RSGIS Unconference - EcoSciences Precinct, Brisbane, March 2013.
- Australian Executive Award - OBIA at Aberystwyth University, May 2012.
- Meeting at University of Trier, Germany, June 2012.
- Meeting with GA - Unlocking the Landsat Archive Project, July 2011.
- Meeting with Steve Prince - NASA Carbon Cycle & Ecosystems, August 2011.
- National Nested Grid Worksheet, September 2011.
- CSIRO Meeting, September 2011.
- ABARES Meeting, September 2011.
- JAXA K&C III Workshop, Tokyo, October 2011
- Auscover Queensland Node User Meeting
- ACEAS Spatial Prioritisation Working Group, November 2011

FIELD CAMPAIGNS

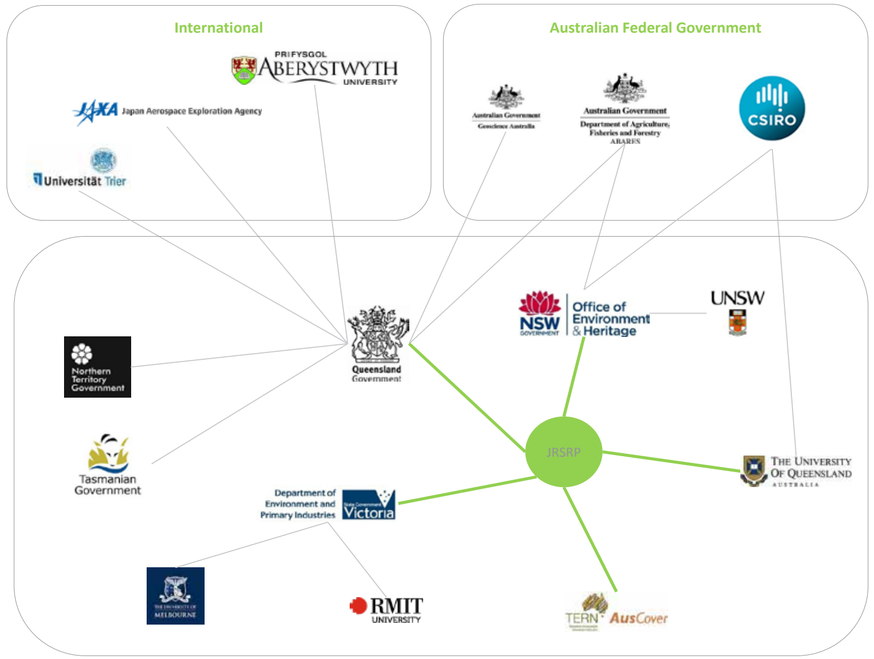
Lichfield National Park, NT – May 2013

Chowilla Auscover field trip - January 2012

Robson Creek Auscover Field Trip - September 2012

Below: Collecting soil samples.

COLLABORATIONS



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DATA PUBLISHING

Visit the Product Pages of the Auscover Remote Sensing Data Facility wiki data.auscover.org.au

Land Cover

- Fractional cover - Landsat, Joint Remote Sensing Research Program algorithm, Australia coverage
- Vegetation height - IceSat, Queensland coverage

Radiation, Meteorology and Ancillary

Landsat Cloud, Shadow and Water mask - Australia coverage

Site-based Datasets

Nadir BRDF Adjusted Reflectance (NBAR) - Landsat, JRSRP algorithm, Supersites.

STAFF

QUEENSLAND DSITIA

Christian Witte

Peter Scarth
Broad remote sensing interests in rangeland, forest and aquatic environments. Happiest when producing automated, operational and validated national scale products that can be used by scientists, policy and the public.

Dan Tindall
Large-area and location specific remote sensing of vegetation cover and dynamics including ground cover, woody vegetation, fire, habitat and biomass using a range of sensors and platforms. Mapping and modelling of erosion using terrestrial and airborne laser scanning and high and low resolution imagery and biophysical data. Communication and distribution of research and applications. Conversion of research into relevant, operational applications to support government policy and public interest initiatives.

Neil Flood
Radiometric and geometric corrections to satellite imagery and robust, high quality software design for scientific data processing.

John Armston
Remote sensing of vegetation structure for environmental mapping and monitoring programs in Eastern Australia. Recent work has included retrieval of canopy properties from airborne waveform Lidar, open source software for airborne and terrestrial Lidar and above-ground biomass mapping from ALOS PALSAR.

Rebecca Trevithick
Enabling systems for spatial data management and analysis. Spatial data quality and error analysis.

Jasmine Muir

STAFF

NEW SOUTH WALES OEH

Tim Danaher
Development of calibrated and validated remote sensing products that assist with operational monitoring and management of vegetation.

Tony Gill
The use of remote sensing data for large-area land-cover mapping. Tony has produced woody-vegetation extent and cover maps for Australia using time-series of MODIS and Landsat data, and is currently working on woody vegetation extent and cover maps for NSW at 5 m spatial-resolution using SPOT 5 imagery.

Adrian Fisher
Developing processing methods for satellite and airborne data, to support regional environmental monitoring.

VICTORIA DEPI

Andrew Mellor
Monitoring and reporting changes in the extent and condition of Australian native public forest using passive and active remote sensing technology.

Andrew Haywood
Remote sensing and resource mapping. In particular, issues of scale, data uncertainty and the processes of validating and understanding remotely sensed imagery for land management.

STAFF

UNIVERSITY OF QUEENSLAND

Stuart Phinn
Use of satellite and airborne images to map, monitor and model biophysical properties of terrestrial and aquatic environments for scientific and management applications.

Kasper Johansen
High spatial resolution remote sensing, object-based image analysis, integration of field and image data for riparian and urban environments.

Chris Roelfsema

Mitch Lyons
Remote sensing and spatial analysis of terrestrial and aquatic ecosystems using a range of image types, with special interest in time-series analysis, object-based image analysis and coastal environments.

Jo Edkins
Program administration and support.

FACILITIES & RESOURCES

Qld Department of Science, Information Technology, Innovation and the Arts - Remote Sensing Centre

- Fully supported DSITIA 800 core High Performance Computing and file store
- Archive of 80,000 fully corrected Landsat Images across Australia
- Archive of full waveform and discrete Lidar over multiple sites across the state
- Archive of SPOT 5 imagery for 2009
- Riegel VZ-400 Terrestrial Laser Scanner
- VIS and NIR Hemispherical Cameras
- Fully supported field 4WD, complete with vegetation survey equipment and field laptops and tablets
- Software including Imagine, Envi, Arcmap and open source software

University of Queensland

The School of Geography, Planning and Environmental Management is well resourced with a wide range of modern, well maintained field, lab and safety equipment. The Biophysical Remote Sensing Group and the JRSRP specifically use the following resources:

Field Instruments

- ASD-Field Spec UV/VNIR calibrated field spectrometer with optics for measurement of radiance, irradiance and reflectance (350-1050nm) in terrestrial and submarine environments
- Multiple ASD-Field Spec Full Range VIS-NIR-SWIR calibrated field spectrometers with optics for measurement of radiance, irradiance and reflectance
- Multiple ASD Hand held spectrometers
- ASD Integrating Sphere
- Sun Photometer's
- LiCOR plant canopy analyser and optical sensor
- TRAC (Tracing Radiation and Architecture of Canopies) hand-held instrument for measuring photosynthetic photon flux density and estimating canopy gap fraction and leaf area indices
- A large collection of digital camera equipment

IT

Hardware

- 30 PC dedicated GIS/RS lab
- 20+ PC general lab
- 15 PC postgraduate lab
- Access to the UQ High Performance Computing Facility

Software

- ESRI site license, including ArcGIS
- Beta site for Erdas Imagine
- Beta site for ENVI/IDL
- Definiens eCognition Professional
- Atmospheric correction and radiative transfer models (Modtran, Hitran, ATREM, FLAASH)
- IDRISI
- Sigma-0 (JPL SAR software)
- HYPEX (hyperspectral / atmospheric correction code)
- Fragstats
- Stella
- Matlab
- Primer and Statistica

NSW Office of Environment and Heritage

- Landsat images over NSW spanning 1987–2012
- Annual Statewide SPOT 5 imagery from 2008–2012.
- Unix computing cluster and multi-petabyte data storage facility
- Software including Imagine, Envi, ArcMap and open source software
- Several planar digital stereo workstations
- Field work equipment
- ADS40/80 aerial imagery for two thirds of the NSW
- Discrete return Lidar data for many project areas
- Access to ADS80 digital scanner and Leica LIDAR for data capture in NSW

FINANCIAL STATEMENT

Statement of operating income and expenditure to end of financial year June 2013. Explanatory notes over-page.

Income	Note	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	Total
UQ	1							0.00
DSITIA	1		349,090.91	166,317.00		180,824.00		696,231.91
OEH	1		450,000.00		280,000.00		10,000.00	740,000.00
DEPI	1					149,000.00	50,000.00	199,000.00
Total Income			**799,090.91**	**166,317.00**	**280,000.00**	**329,824.00**	**60,000.00**	**1,635,231.91**
Funds brought forward			0.00	567,738.50	451,865.75	478,567.20	541,262.25	
Total Funds Available			799,090.91	734,055.50	731,865.75	808,391.20	601,262.25	
Expenditure								
Salaries	2		106,344.85	277,530.02	236,453.40	197,020.11	202,360.58	1,019,708.96
Overheads	3					59,633.45	5,454.55	65,088.00
Consumables	4		200.00	756.61		924.50	248.90	2,130.01
Services	5		121,236.37					121,236.37
Equipment	6							0.00
Travel & Hospitality	7		3,571.19	3,903.12	16,845.15	9,550.89	13,842.21	47,712.56
Total Expenditure			**231,352.41**	**282,189.75**	**253,298.55**	**267,128.95**	**221,906.24**	**766,840.71**
Funds Carried Forward			**567,738.50**	**451,865.75**	**478,567.20**	**541,262.25**	**379,356.01**	

1. In-Kind Contributions	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	Total
UQ	235,320.00	235,320.00	280,320.00	374,820.00	468,278.00	386,351.00	1,980,409.00
DERM	153,017.00	200,140.00	179,877.00	210,706.00	366,554.00	163,899.00	1,274,193.00
OEH		115,000.00	115,000.00	115,000.00	117,500.00	126,740.00	589,240.00
DEPI				76,000.00	33,000.00	44,000.00	153,000.00
Total In-Kind	**388,337.00**	**550,460.00**	**575,197.00**	**776,526.00**	**985,332.00**	**720,990.00**	**3,996,842.00**
2. Salaries							
DSITIA		53,172.43	158,907.08	87,716.19	51,653.25	65,576.00	417,024.95
OEH		53,172.43	118,622.94	117,061.99	112,485.99	107,698.82	509,042.17
DEPI					32,880.87	29,085.76	61,966.63
Total Salaries		**106,344.86**	**277,530.02**	**204,778.18**	**197,020.11**	**202,360.58**	**988,033.75**
3. Overheads							
DSITIA					16,733.45		16,733.45
OEH					28,000.00	909.09	28,909.09
DEPI					14,900.00	4,545.46	19,445.46
Total Overheads		**0.00**	**0.00**	**0.00**	**59,633.45**	**5,454.55**	**65,088.00**
4. Consumables							
DSITIA		200.00	554.79		803.88	102.63	1,661.30
OEH			208.82		74.98	73.04	356.84
DEPI					45.64	73.23	118.87
Total Consumables		**200.00**	**763.61**	**0.00**	**924.50**	**248.90**	**2,137.01**
5. Services							
DSITIA		86,236.37					86,236.37
OEH		35,000.00					35,000.00
Total Services		**121,236.37**	**0.00**	**0.00**	**0.00**	**0.00**	**121,236.37**
7. Travel & Hospitality							
DSITIA		2,495.02	3,024.85	15,543.70	4,922.70	8,340.23	34,326.50
OEH		1,076.17	878.27	1,301.45	4,517.50	2,154.80	9,928.19
DEPI					110.69	3,347.18	3,457.87
Total Travel & Hospitality		**3,571.19**	**3,903.12**	**16,845.15**	**9,550.89**	**13,842.21**	**47,712.56**

GENERAL INQUIRES

The School of Geography, Planning and Environmental Management
University of Queensland
Brisbane, Queensland 4072
AUSTRALIA

phone +61 7 3365 6455 • Fax +61 7 3365 6899 • email jrsrp@uq.edu.au • www.gpem.uq.edu.au/jrsrp