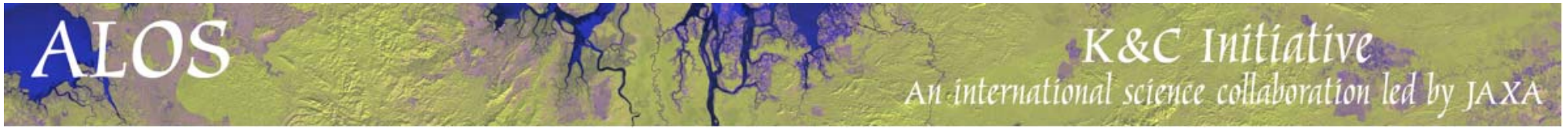


K&C Phase 3

Australian R&D Support to Global Forest and Above Ground Biomass Mapping

Richard Lucas, Daniel Clewley[1]
and Peter Bunting
Institute of Geography and Earth Sciences, Aberystwyth University
Aberystwyth, Ceredigion, SY23 2EJ, UK
rml@aber.ac.uk

John Armston, Peter Scarth, Alex Held, Stuart Phinn, Michael Schmidt
Joint Remote Sensing Research Program/Auscover - Terrestrial Ecosystem Research Network.

Arnon Accad
Queensland Herbarium/ Department of Science Information Technology Innovation and the Arts.

Joao Carreiras
Tropical Research Institute, Portugal

Paul Siqueira and Yang Lei, University of Massachusetts, US

Science Team meeting #16 – Phase 3 Kick-off
JAXA TKSC/RESTEC HQ, Tsukuba/Tokyo, October 17-21, 2011

[1]*Now at USC with Mahta Moghaddam*

Project area: Focus on Australia

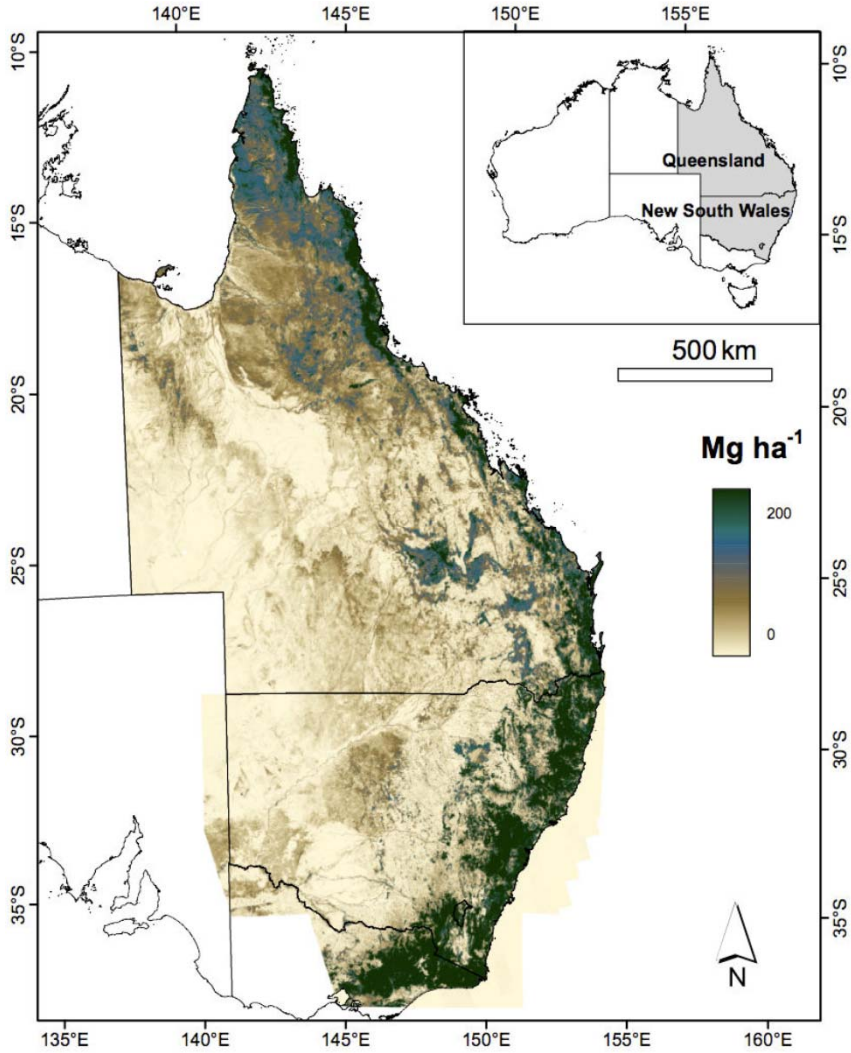
- Focus initially on Queensland.
  - Key LiDAR Sites
  - Change sites (areas affected by cyclones, drought, flooding, fire, clearing, disturbance, degradation, regrowth)
- Extension to New South Wales, Victoria and the Northern Territory
- Subsequent application across Australia

Project objectives and schedule

- To provide R&D support to the generation of JAXA's global forest/non-forest and above ground biomass maps.
  - Advance the development and validation of algorithms by using:
    - Annual, up-to-date statewide forest/non-forest maps (including woodlands) generated from Landsat fractional cover time-series.
    - Field based estimates of AGB generated for a range of remnant and on-remnant forests and woodlands.
    - LiDAR-based assessments of structure, biomass and change.
- Support quantification of:
  - Forest/non-forest extent and change
  - Biomass (carbon)
  - Biomass change and associated carbon losses and gains
- Supporting carbon cycle science, international conventions and environmental conservation

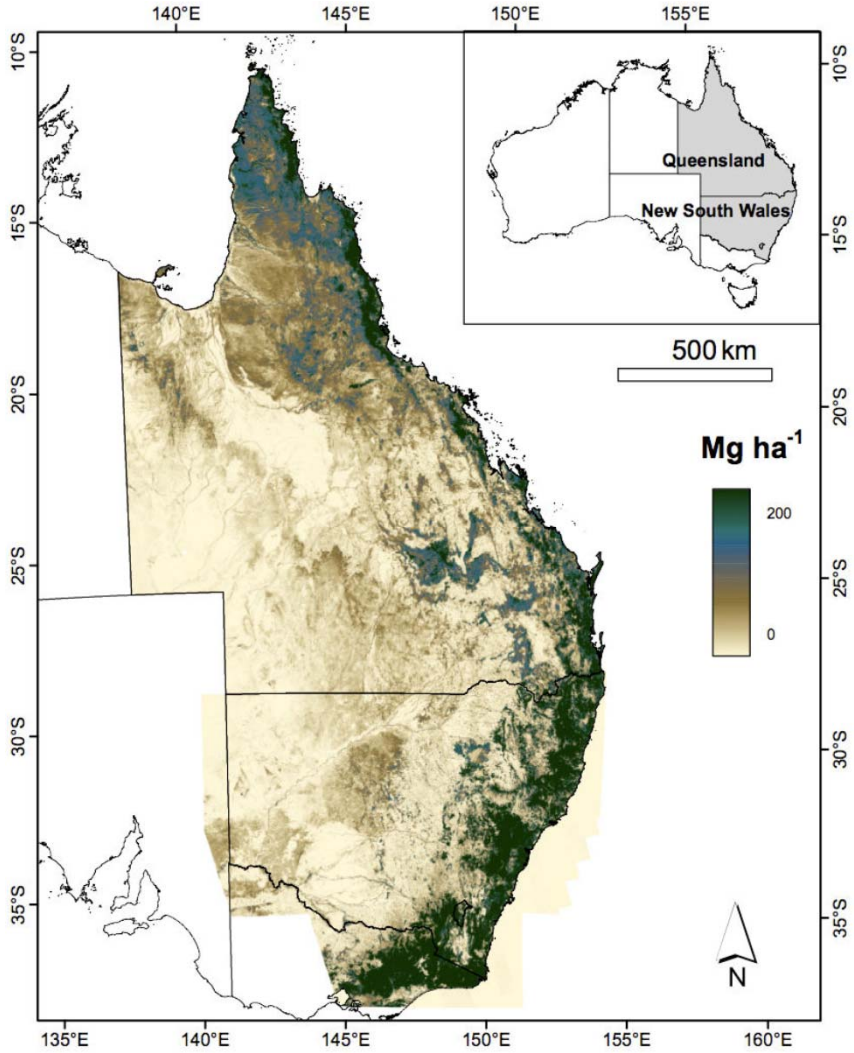
Project schedule

- July, 2012
  - Revised approach to generation of forest/non-forest maps from Landsat sensor data.
  - Extension of AGB map based for Queensland to NSW, the Northern Territory and Victoria (Version 1a)
  - Australian field validation
    - Continued collection of ground and airborne data at sites across Australia
    - Advanced work on retrieval of structural attributes, biomass and change from LiDAR data.
  - Generation of AGB map at 25 m spatial resolution (Version 1b)
    - To be undertaken following finalisation of new products (FPC for Australia) and establishment of advanced methods for biomass retrieval.



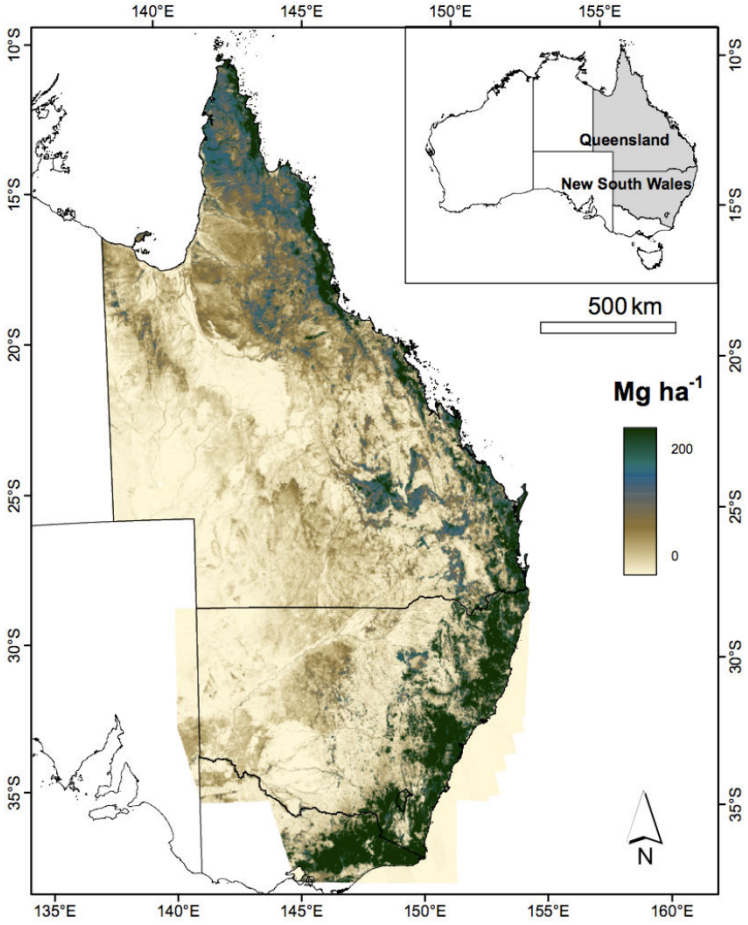
Project schedule

- April, 2013
  - Analysis of case studies in support of JAXA's global forest characterisation, mapping and monitoring
    - Injune
    - Charters Towers
    - Other LiDAR and TERN sites (ALOS-2 proposal also submitted).
    - Other change sites (e.g., for assessing cyclone and fire damage)
  - Advancement of techniques for
    - Forest/non-forest mapping using ALOS-PALSAR
    - Change detection
    - Retrieval of AGB



Project schedule

- April, 2014
  - Generation of Version 2.0 of a 25 m spatial resolution map of AGB for eastern and northern Australia.
- April, 2015
  - Generation of biomass and forest change maps.
  - Extension to Australia



ALOS

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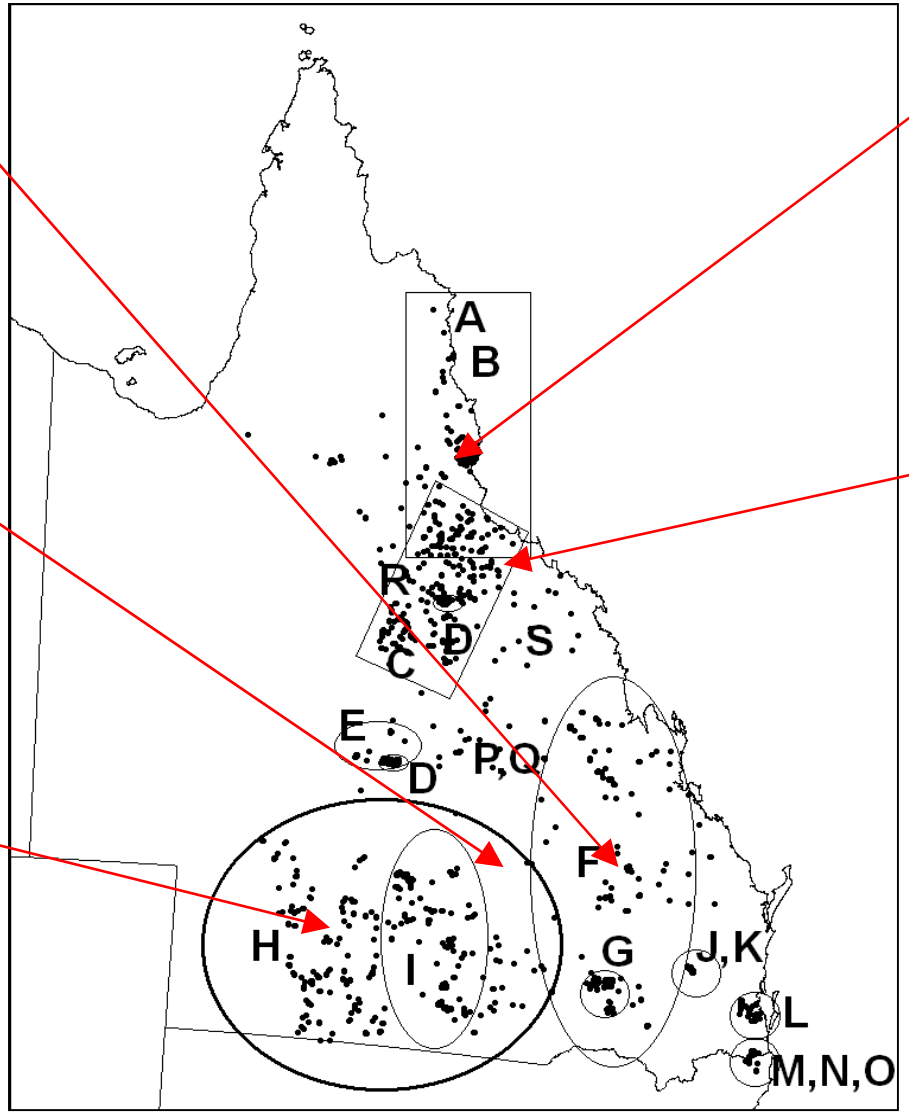
Biomass library - 1139 sites (2781 plots)

Brigalow Forest Regrowth

Open Callitris Forest

Low Acacia Woodland

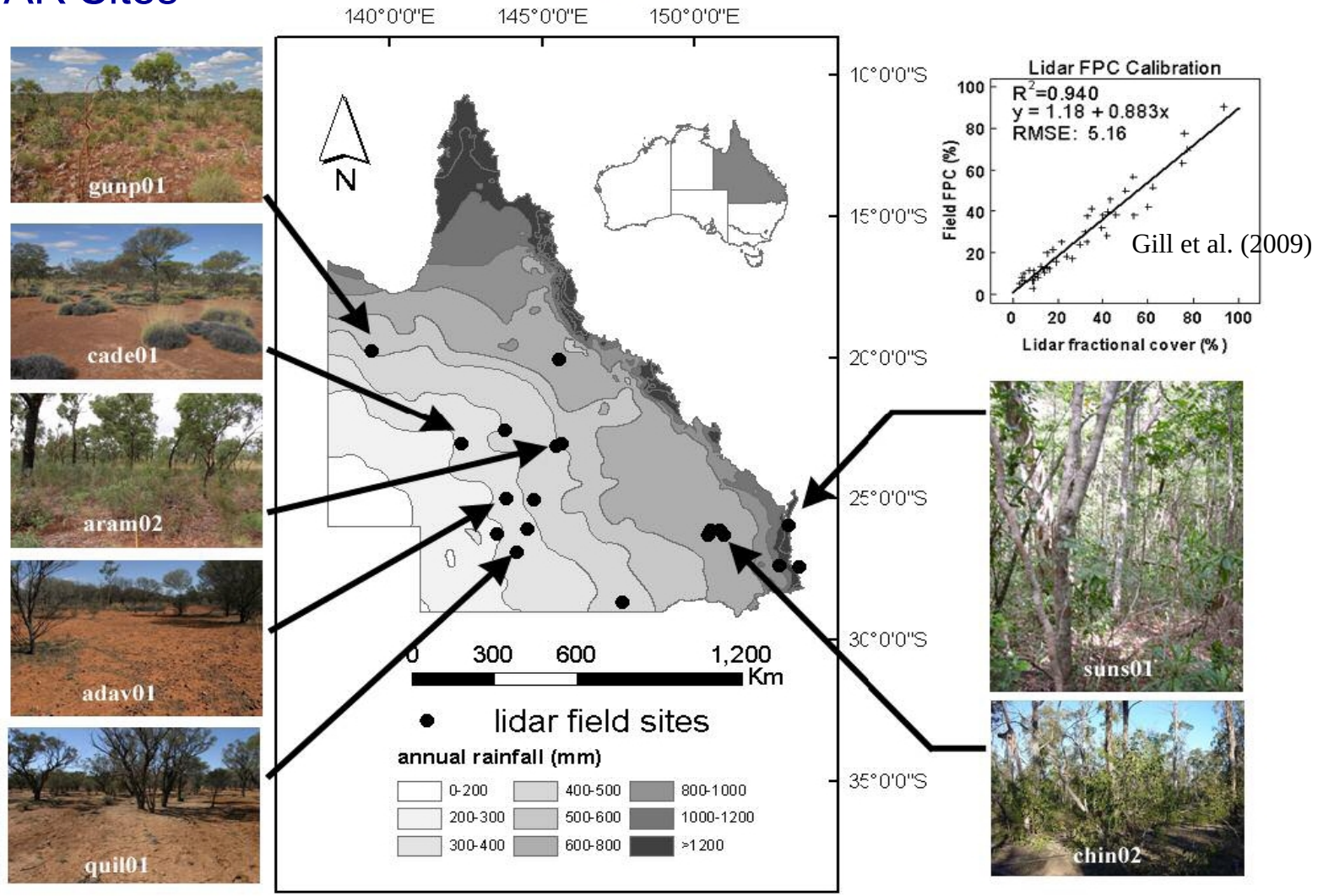


Tall Closed Rainforest

Eucalypt Woodland

Ground truth data for estimating AGB

LIDAR Sites

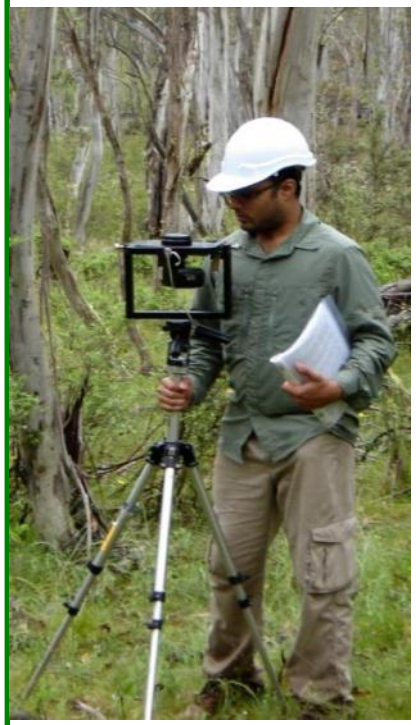


Gill et al. (2009)

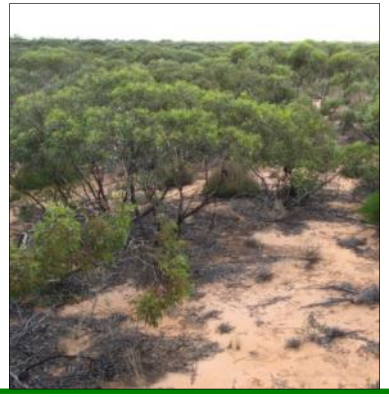
SPDLib and RSGISLib (Bunting et al.,. 2012; open source software supporting visualisation and processing of LiDAR data; remote sensing processing);

Field Campaigns

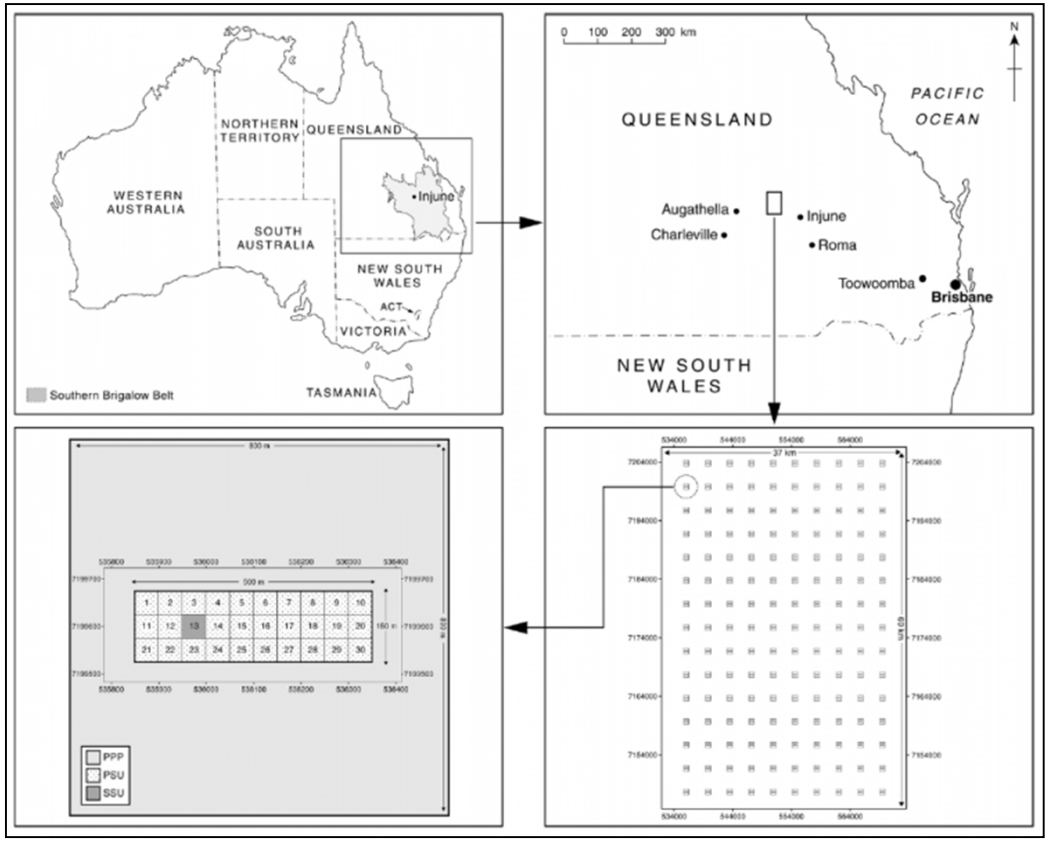


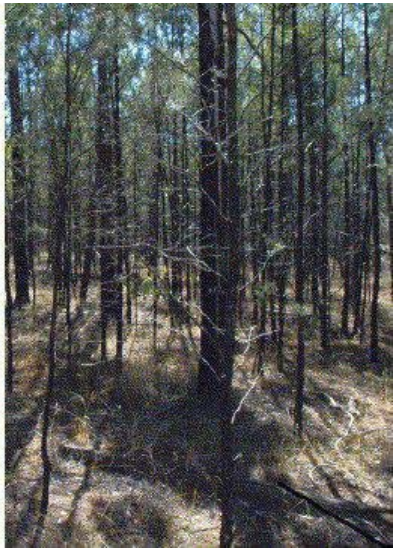





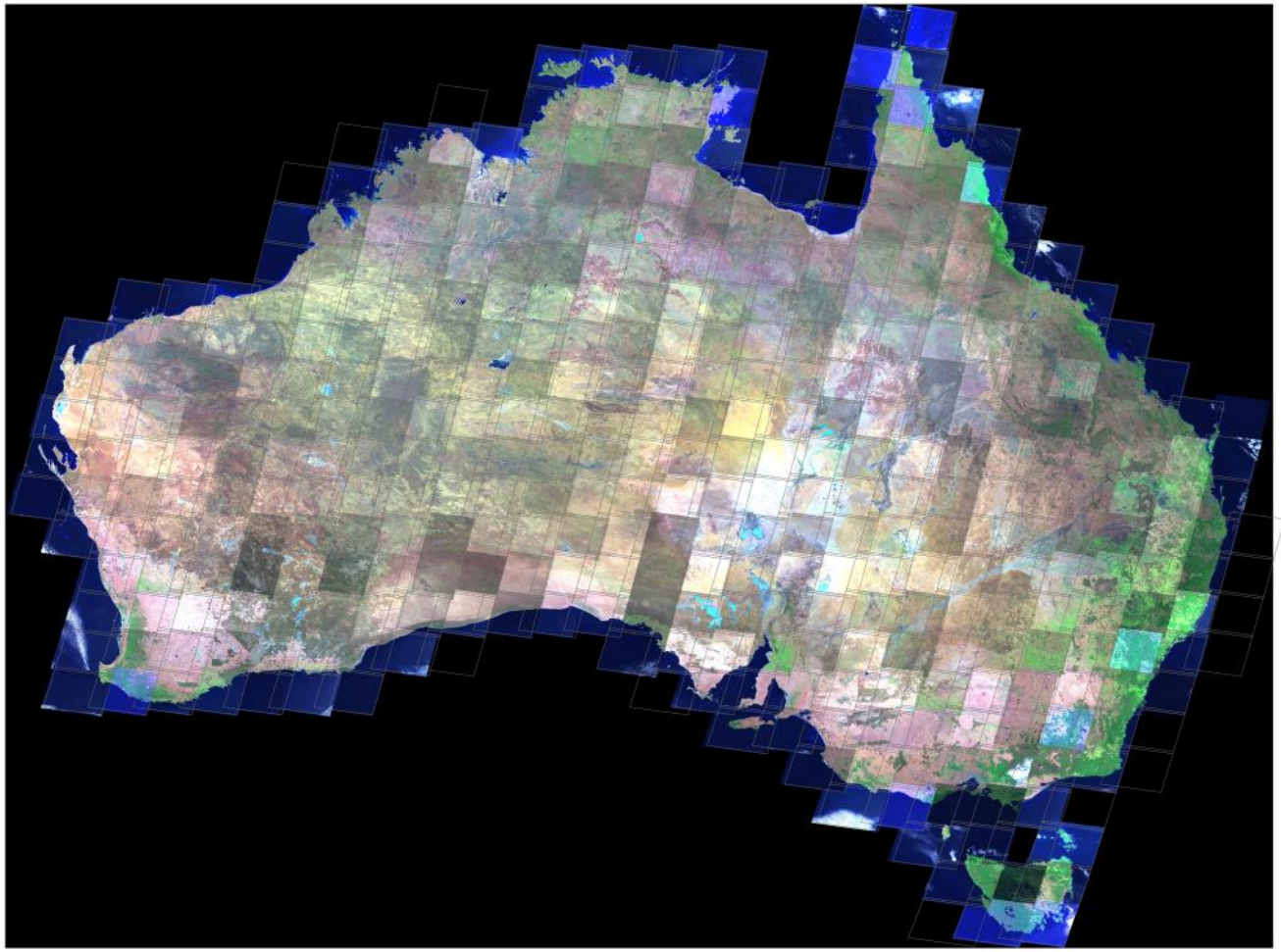
The Injune Landscape Collaborative Project





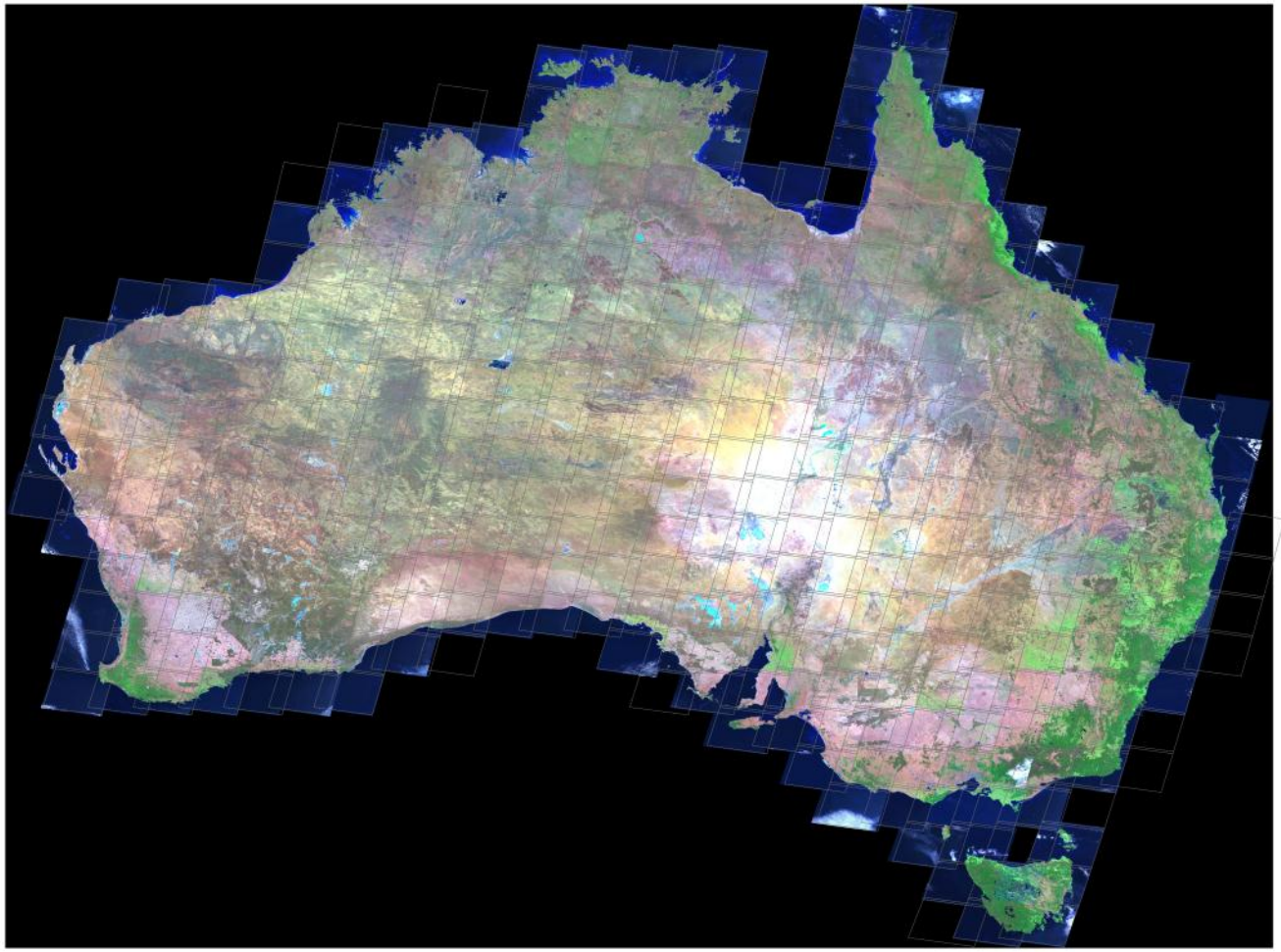
Forest/Non-Forest Mapping/Retrieval of AGB

At-sensor radiance



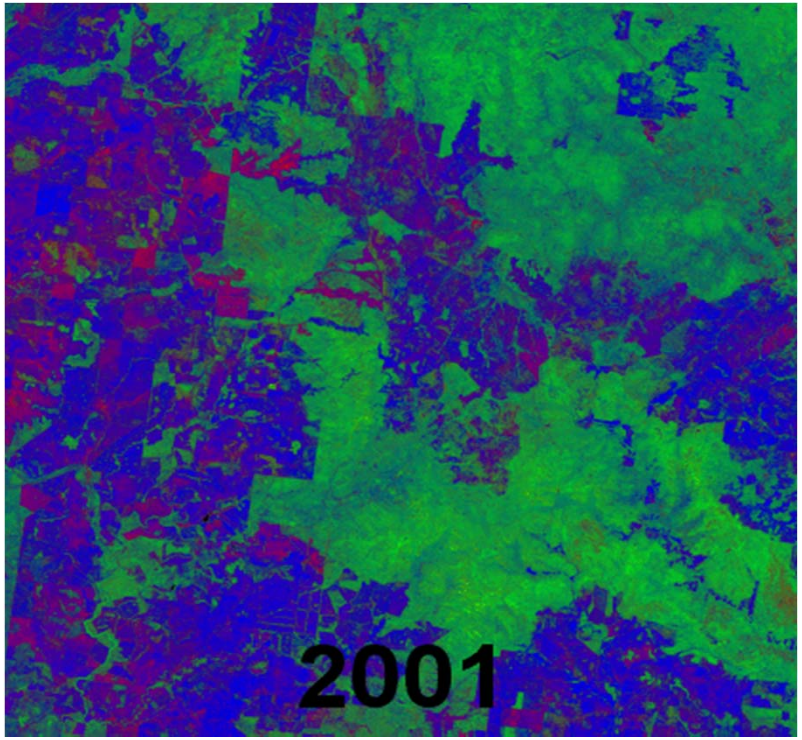
Forest/Non-Forest Mapping/Retrieval of AGB

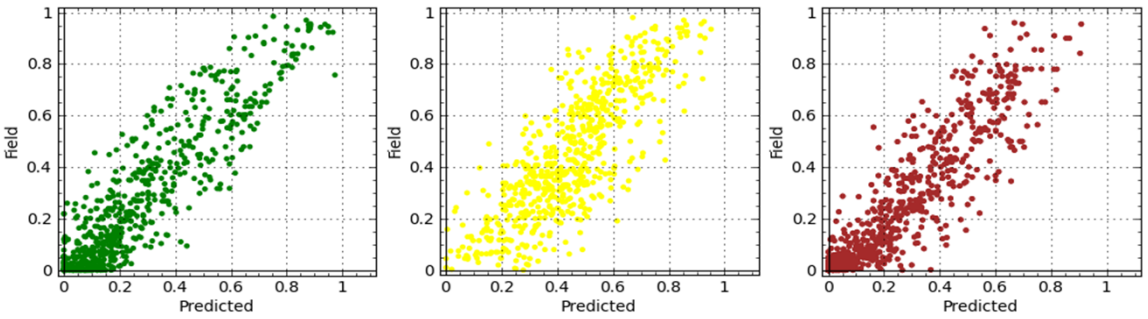
- Standardised reflectance
- Topographic correction
- BRDF correction

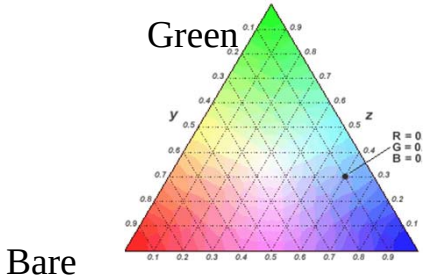


Persistent Green Fraction

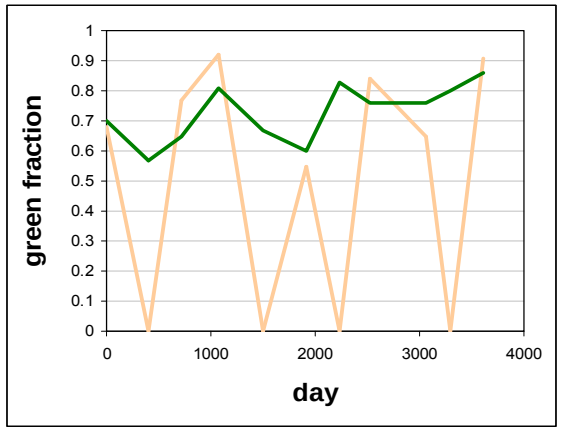
- Fractional cover uses a constrained unmixing model with endmembers derived from field sampling.
- Creates an image with the percentage bare, green and non-green fractions
- Over 800 field sites collected using a consistent, nationally agreed protocol
- Overall RMSE of 11%

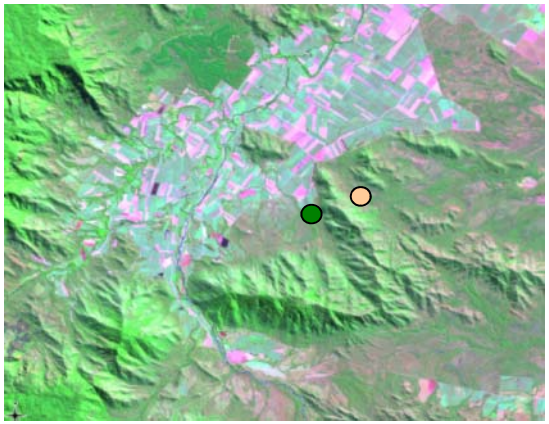




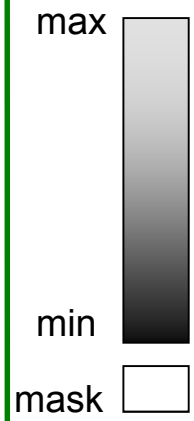


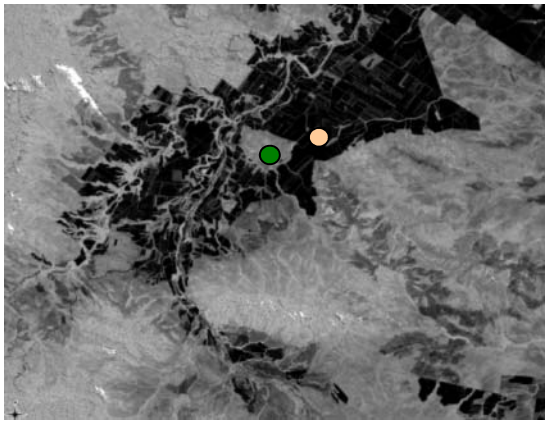
Persistent Green Fraction



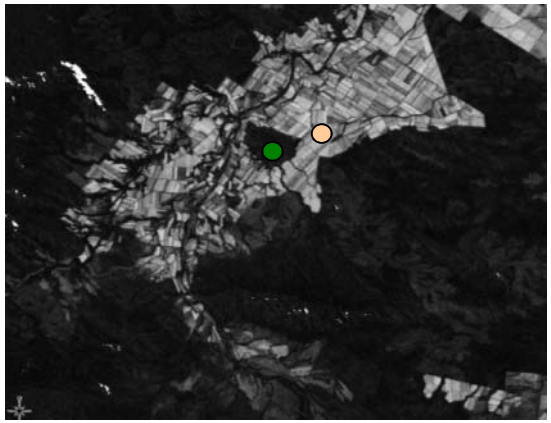


- Robust regression fit to time series of green fraction – robust to account for outliers due to misclassified cloud (or other masked pixel).
- Persistent areas show low variation in green fraction within the time series, and a minimum above a threshold.
- Improved estimation of forest/non-forest

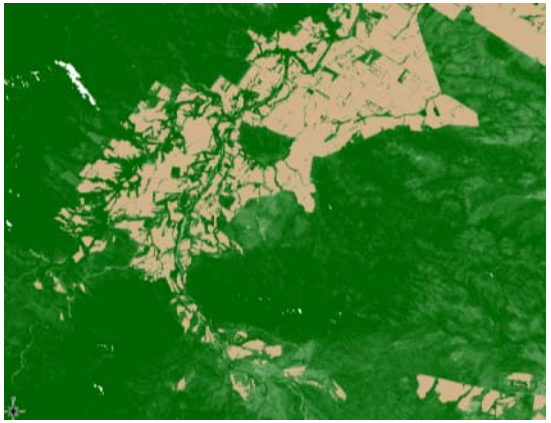




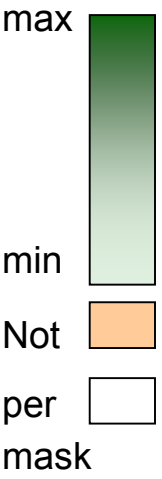
Minimum fraction in time series



Variation in time series



Persistent green fraction

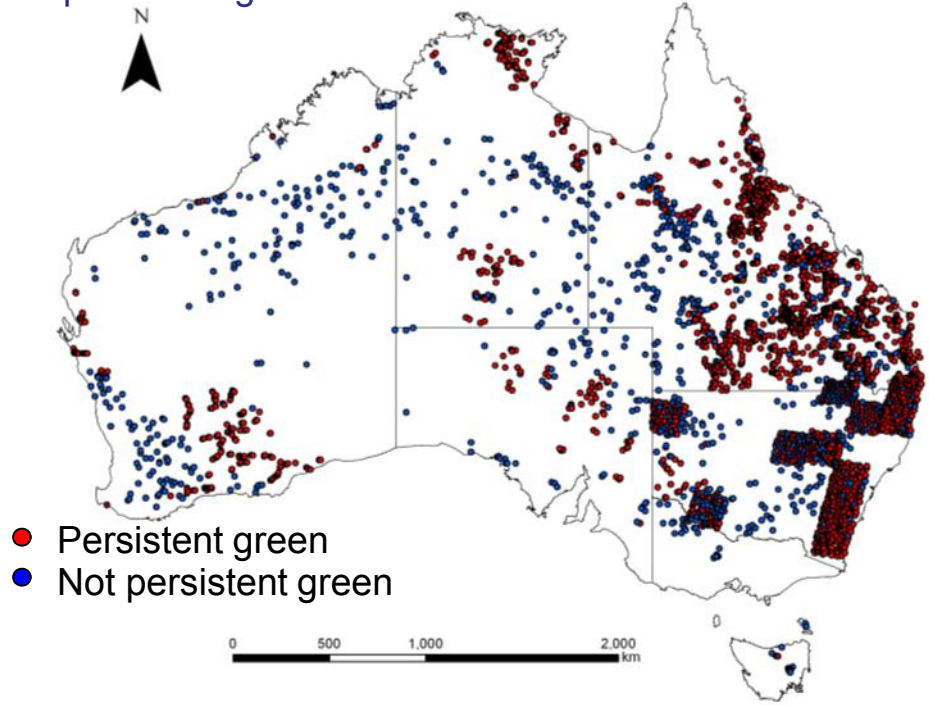


Persistent Green Fraction

- Training data obtained from a range of sources
  - Approx. 5100 sites of which 3800 are persistent green. Star transects at almost 1000 sites.

- Decision tree classifier based on robust regression statistics used to classify each pixel as persistent or not persistent green.

- Robust regression statistics used to predict the persistent green fraction.



SOURCE	DESCRIPTION
QLD DSITIA	Fractional-cover field sites
ABARES	Fractional-cover field sites
NSW OEH	Image-interpretation of woody/not-woody vegetation cover
NT Bushfires	DBH field sites
NT NRETAS	Fractional-cover field sites
ACRIS	Locations of low-foliage scrub
WA	woody-vegetation sampling sites
QLD Herbarium	Biomass field sites

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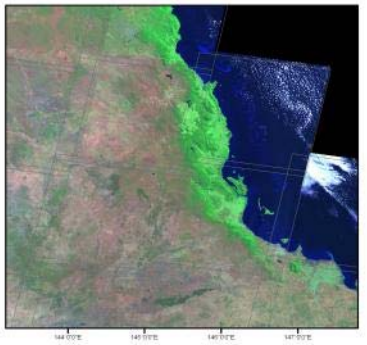
Persistent Green Fraction

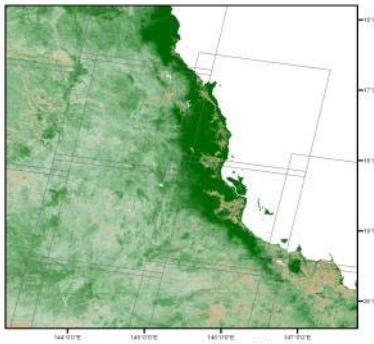
max

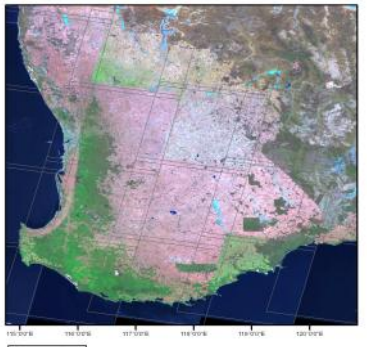
min

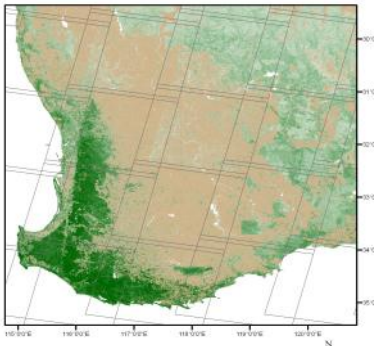
Not per

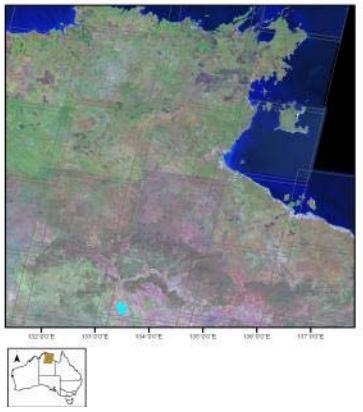
mask

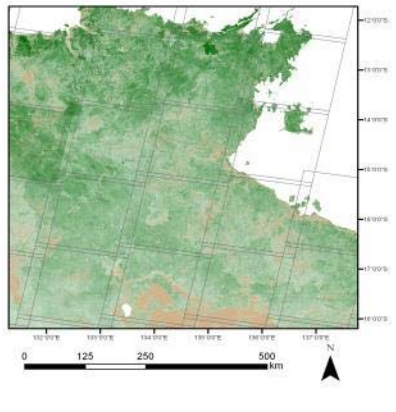


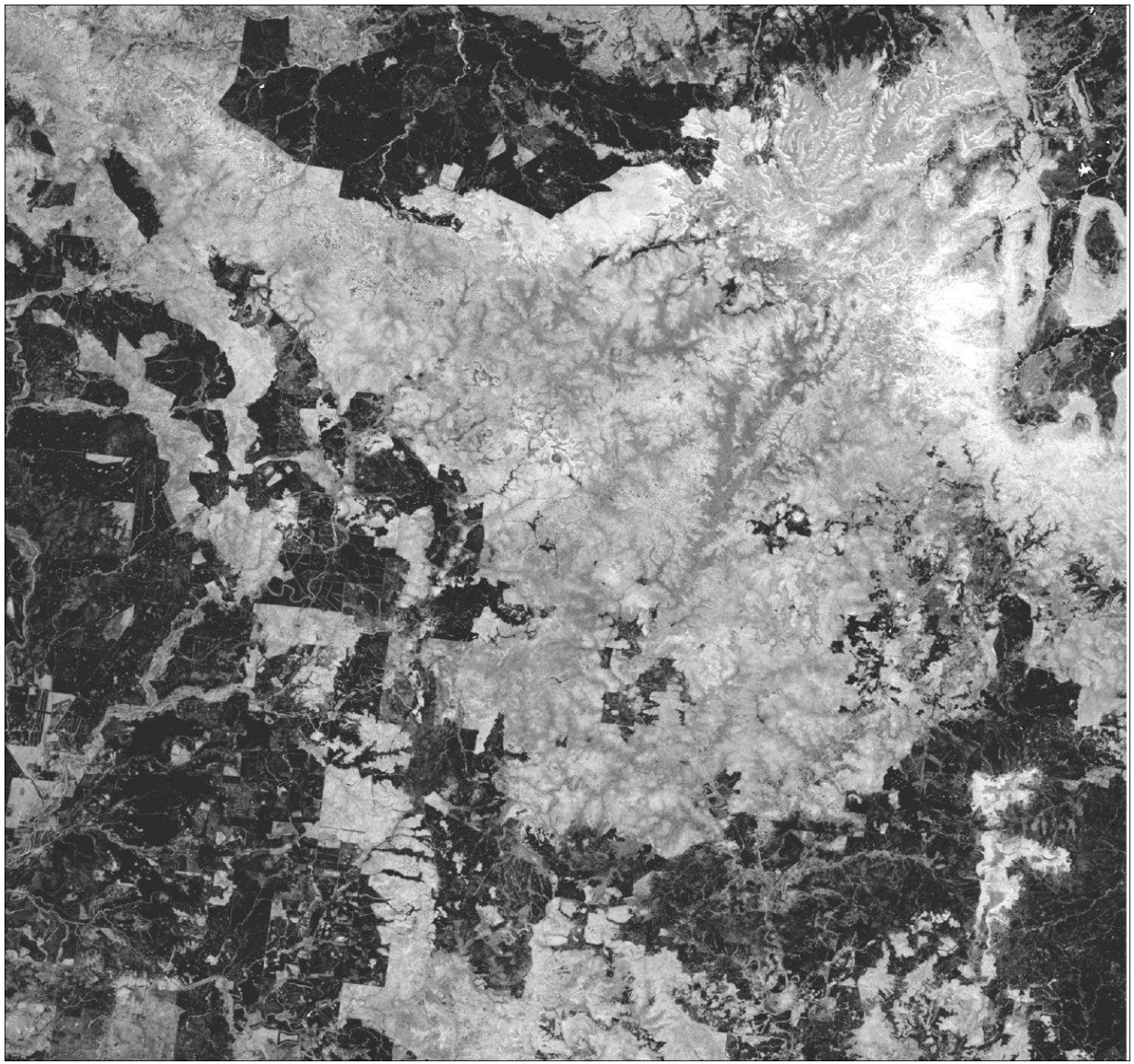












Enhanced Retrieval of AGB

Landsat Foliage Projective Cover

L-band HH

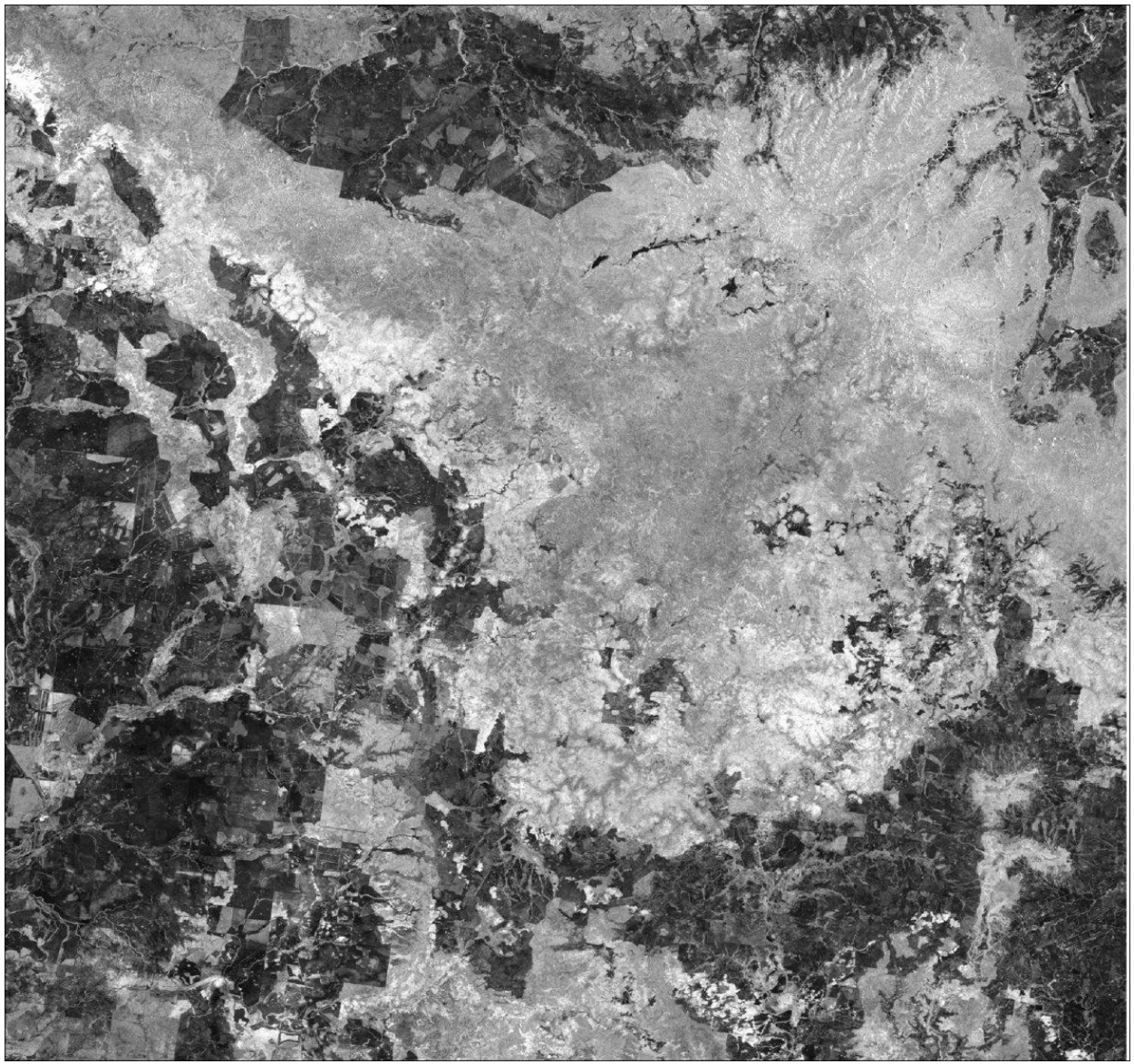
L-band HV

Composite (FPC, L-HH and L-HV)

ICESAT GLAS

Segmentation

Stand Height Retrieval



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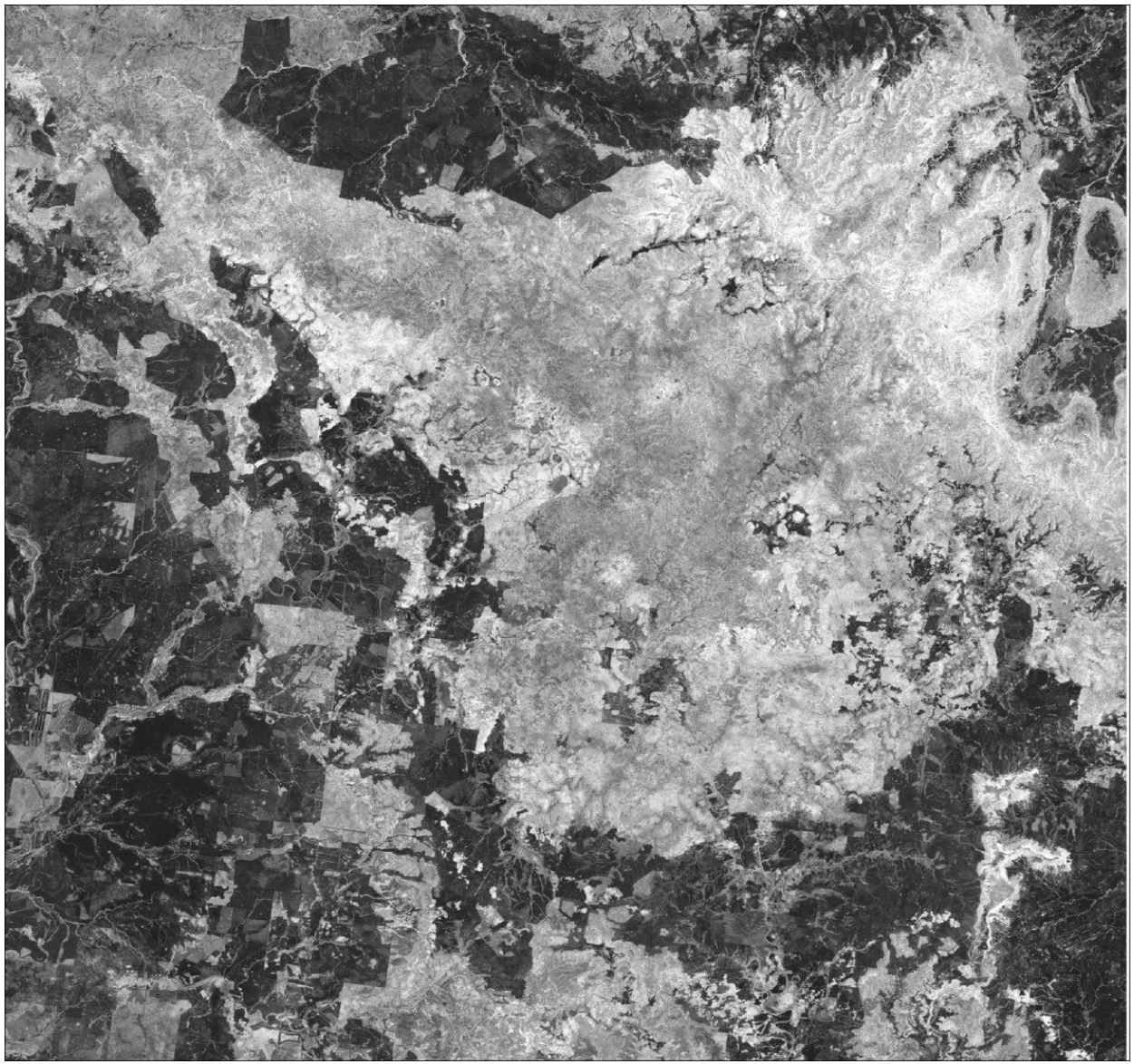

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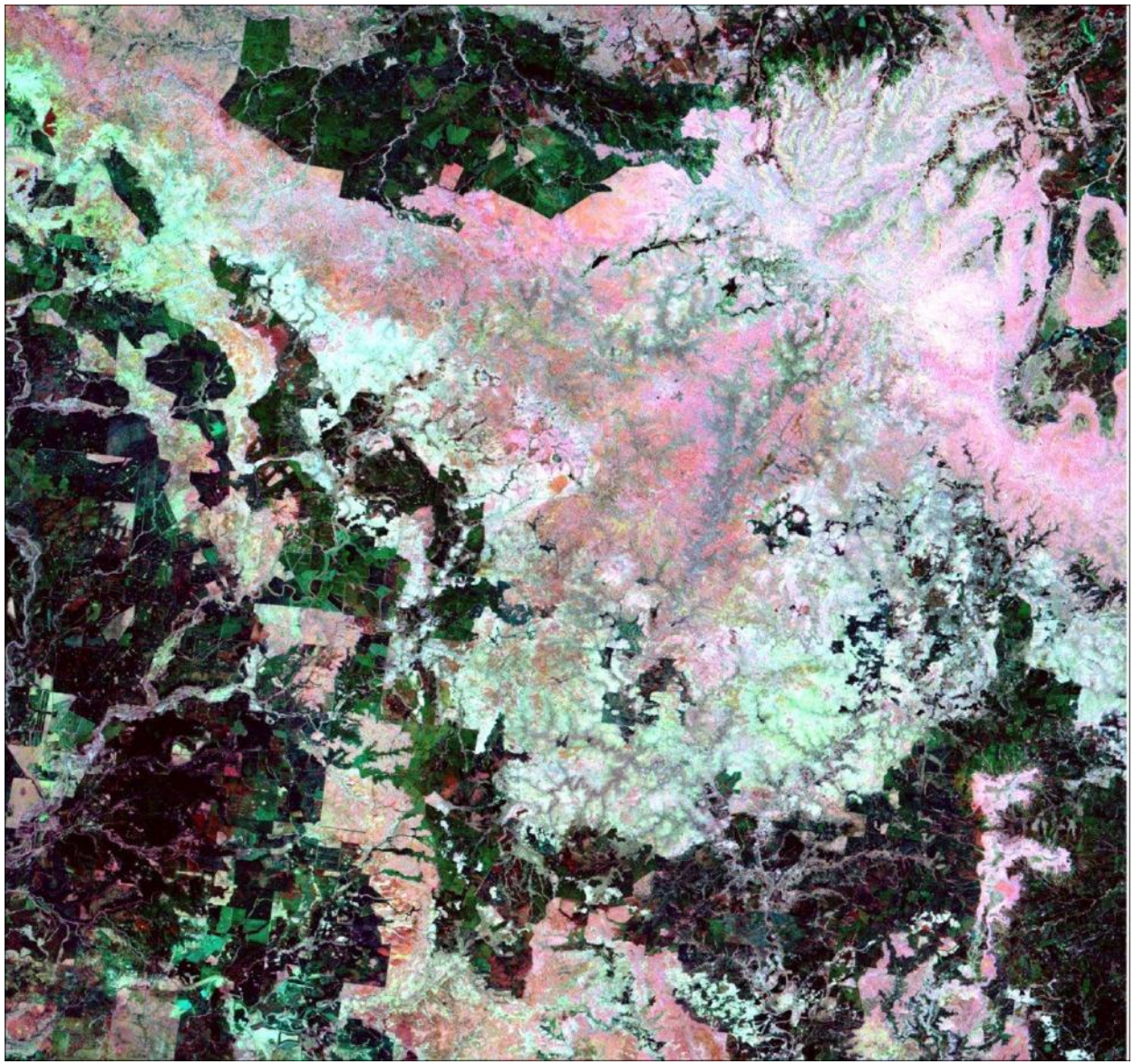

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Enhanced Retrieval of AGB

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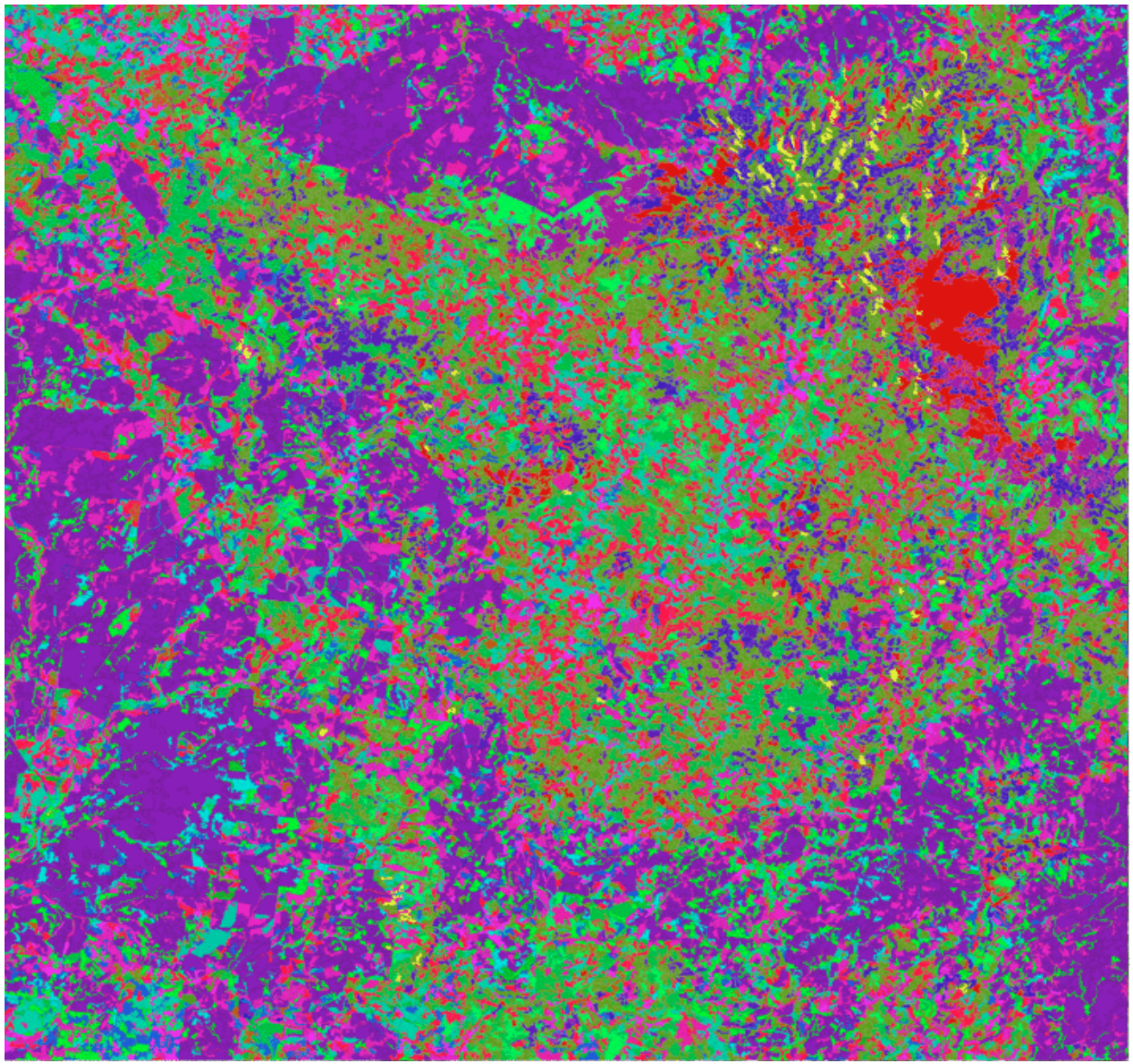
ICESAT GLAS

Segmentation

Stand Height Retrieval



Enhanced Retrieval of AGB

Landsat Foliage Projective Cover

L-band HH

L-band HV

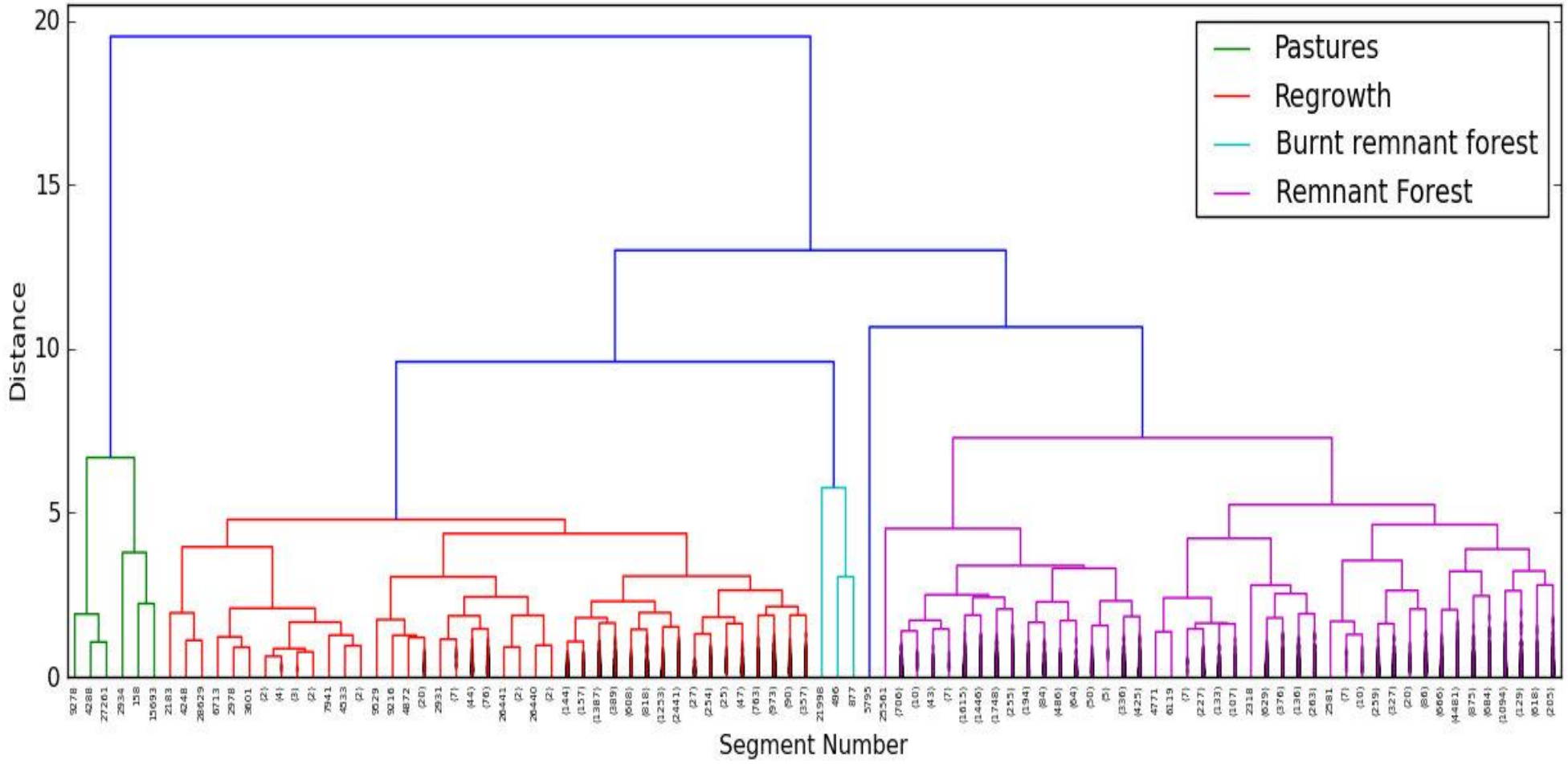
Composite (FPC, L-HH and L-HV)

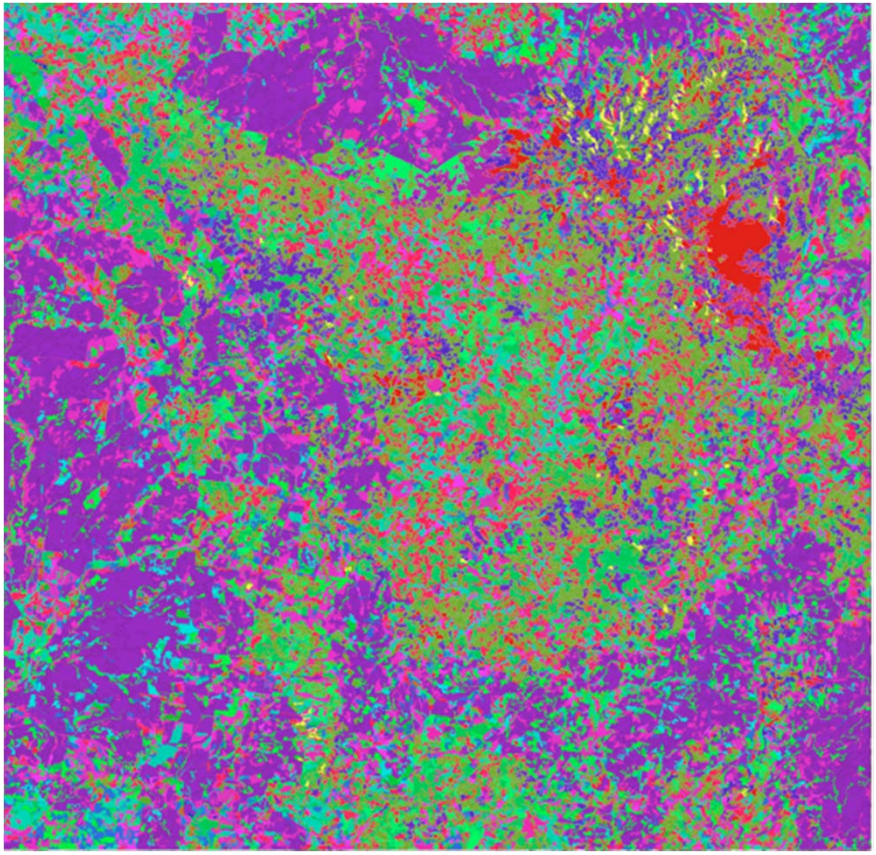
ICESAT GLAS

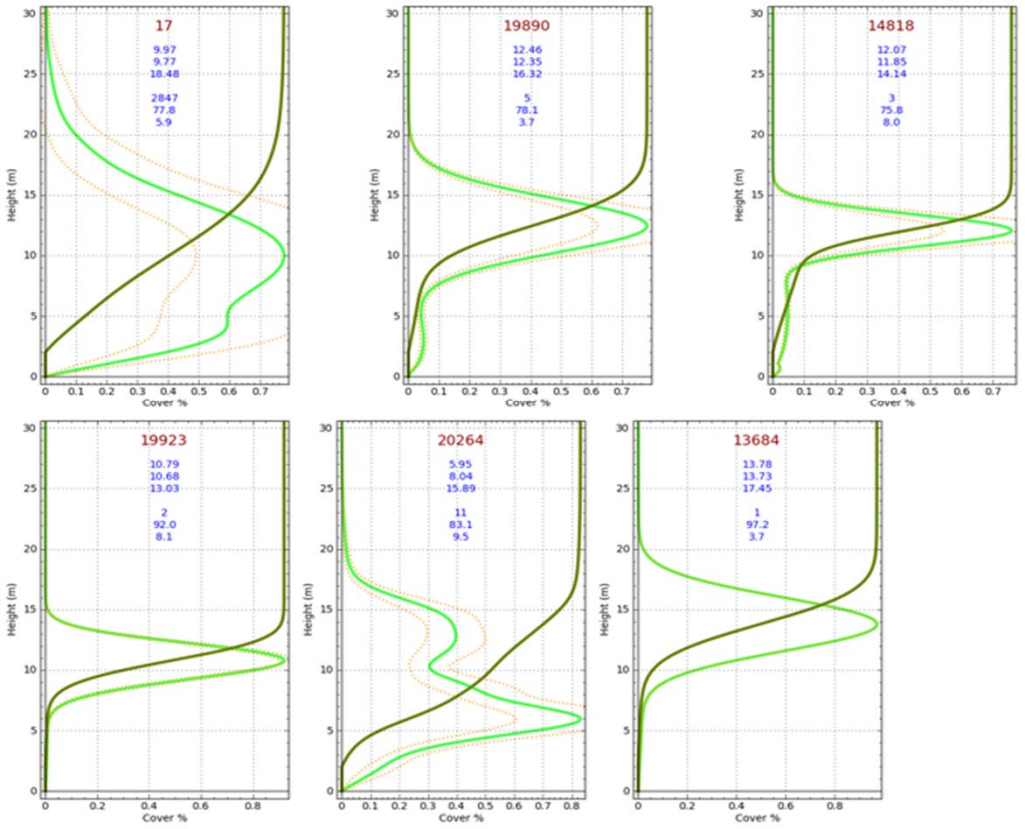
Segmentation

Stand Height Retrieval

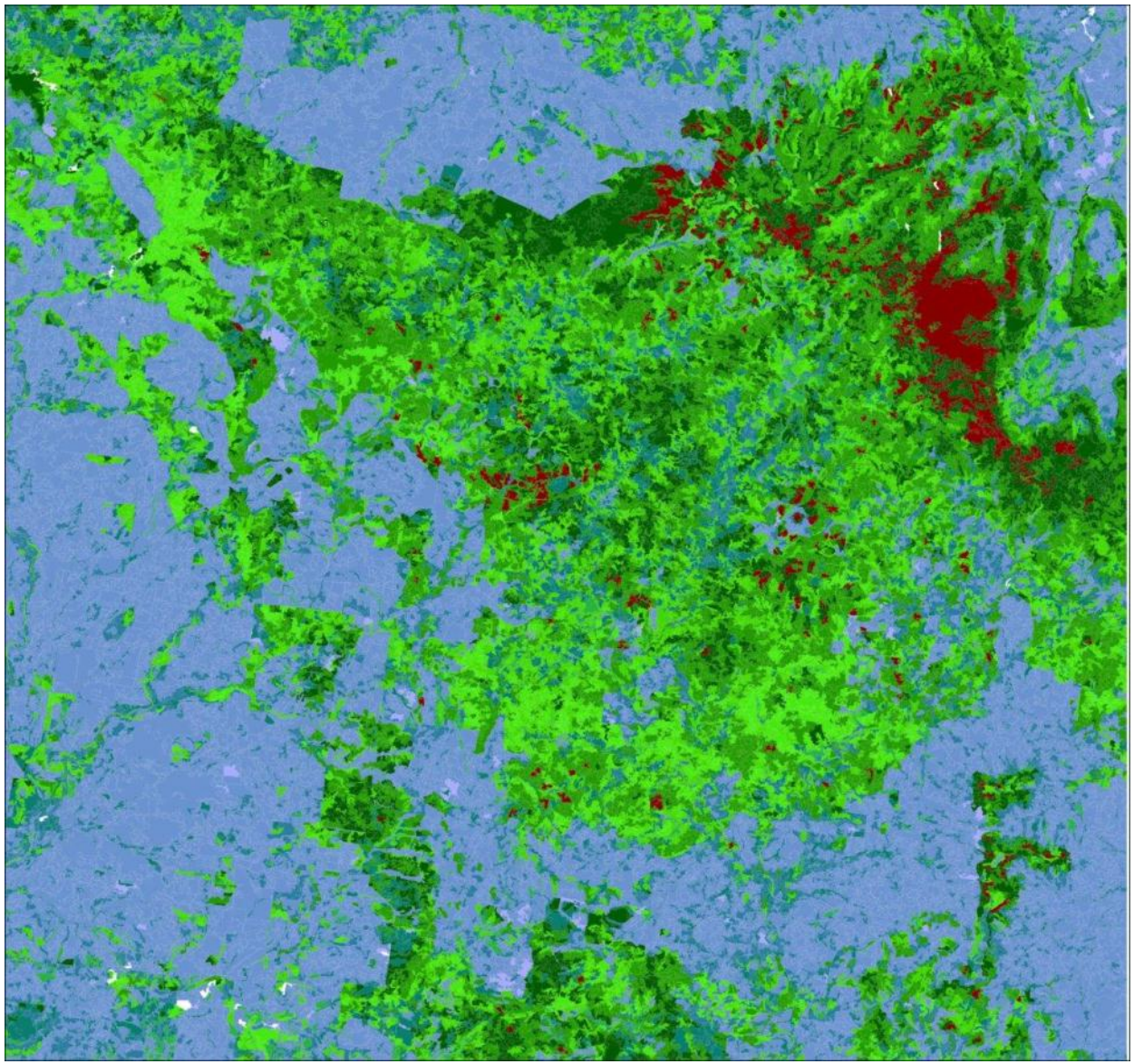
Clustering of Segments (Using SciPy)







- Segmentation based on FPC and L-band HH/HV (40 classes)
- Similar vertical vegetation profiles for each class (e.g., 17)



Enhanced Retrieval of AGB

Landsat Foliage Projective Cover

L-band HH

L-band HV

Composite (FPC, L-HH and L-HV)

ICESAT GLAS

Segmentation

Stand height retrieval

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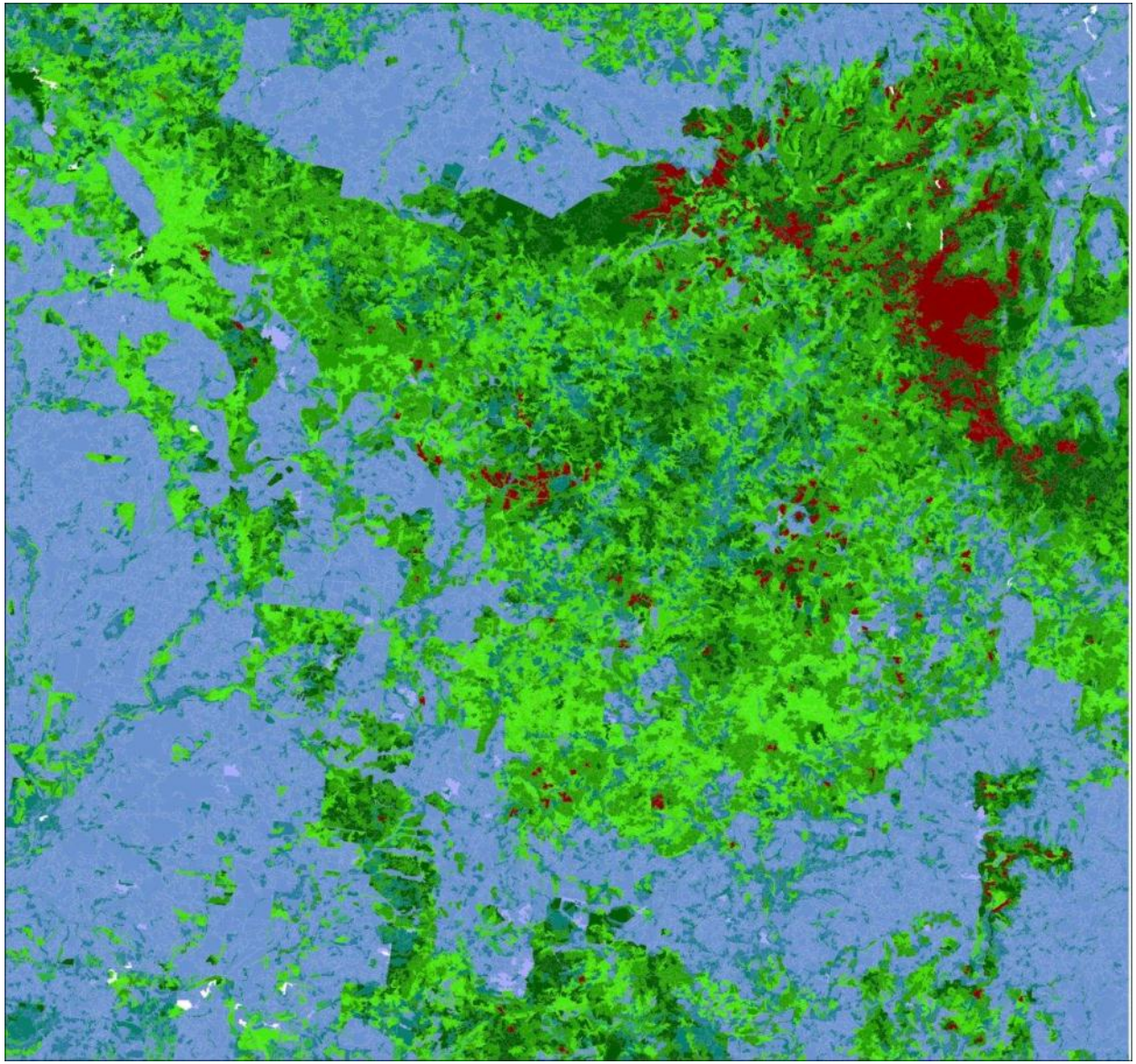
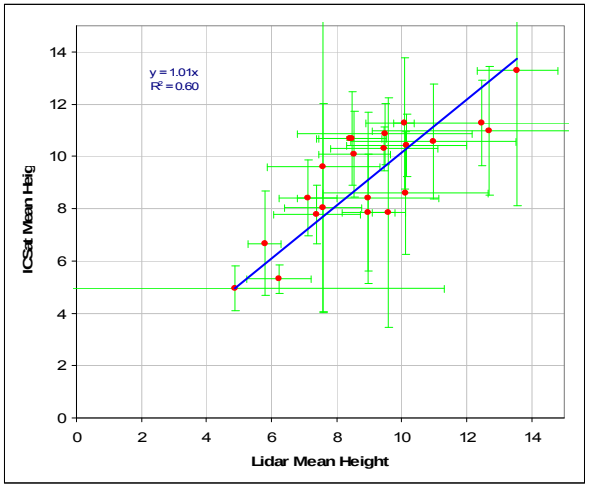
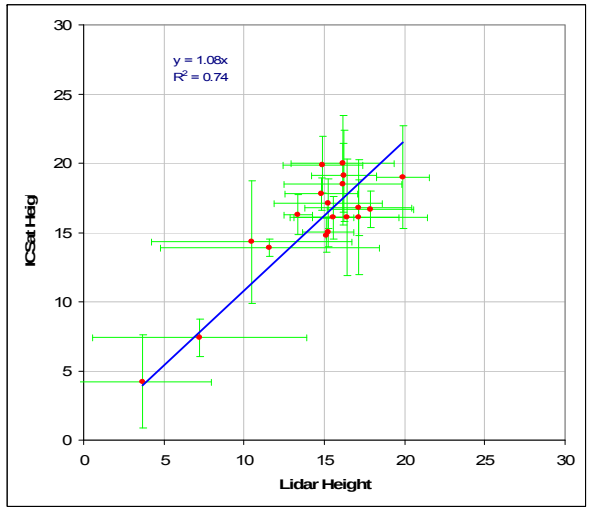




Comparison with ICESAT



Comparison with airborne LiDAR

ALOS

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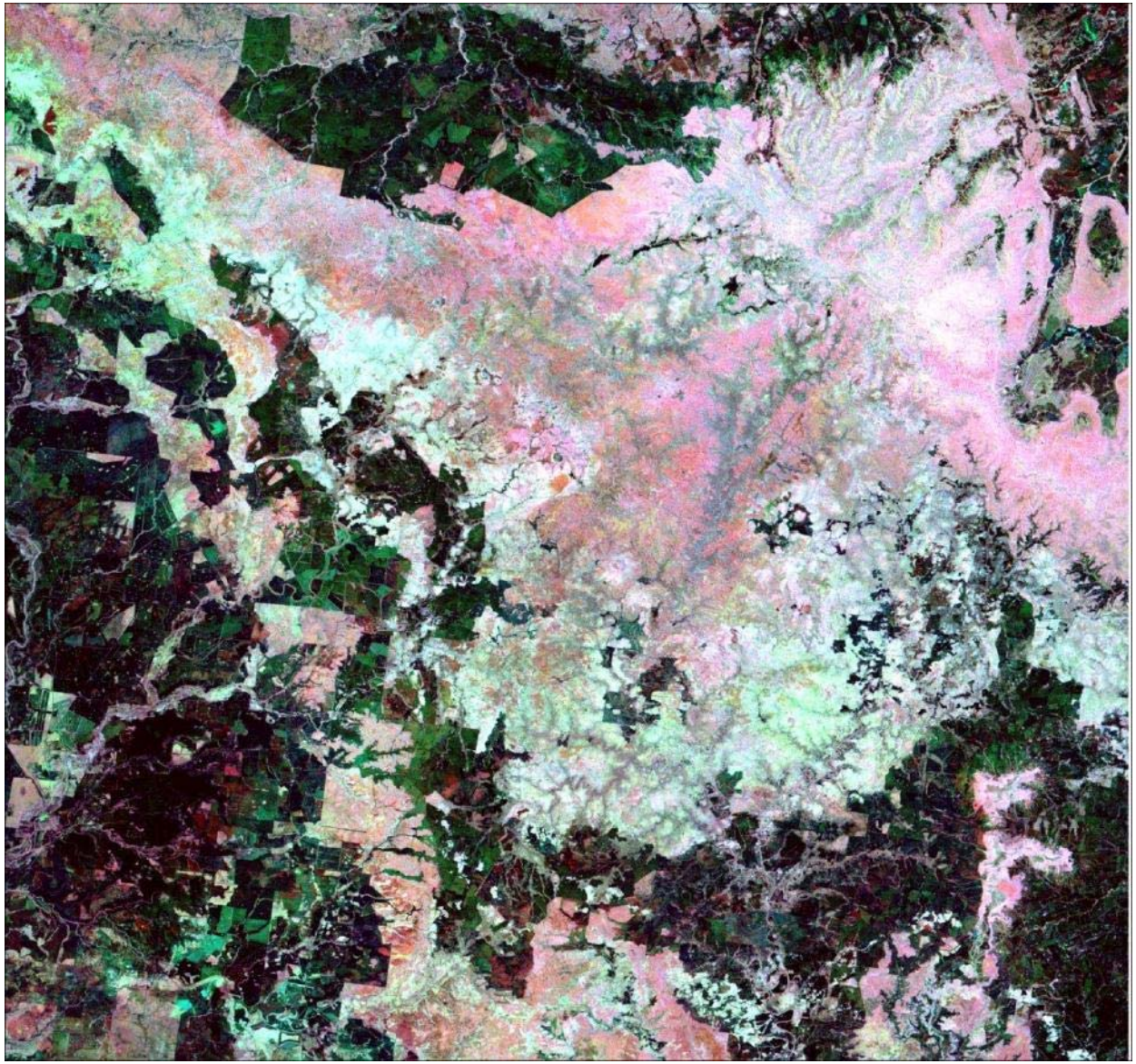
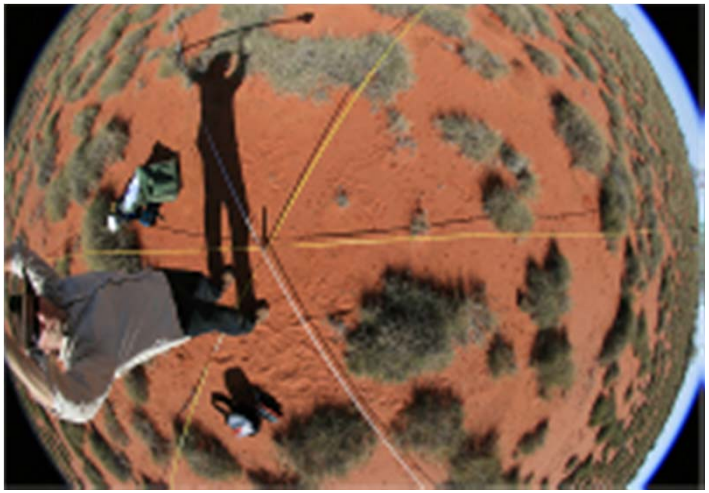




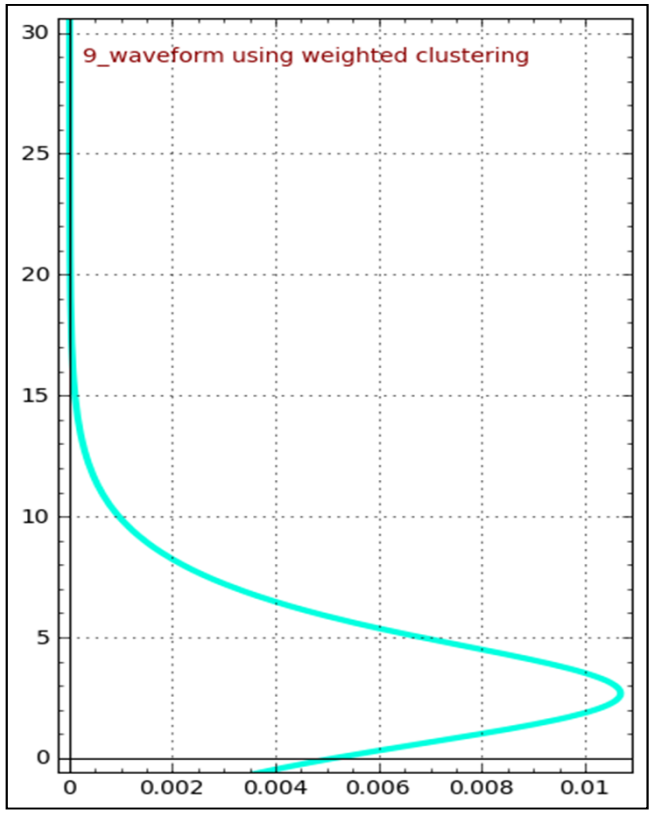
Interpretation of Landsat FPC, L-band HH and HV composites

Early Regrowth

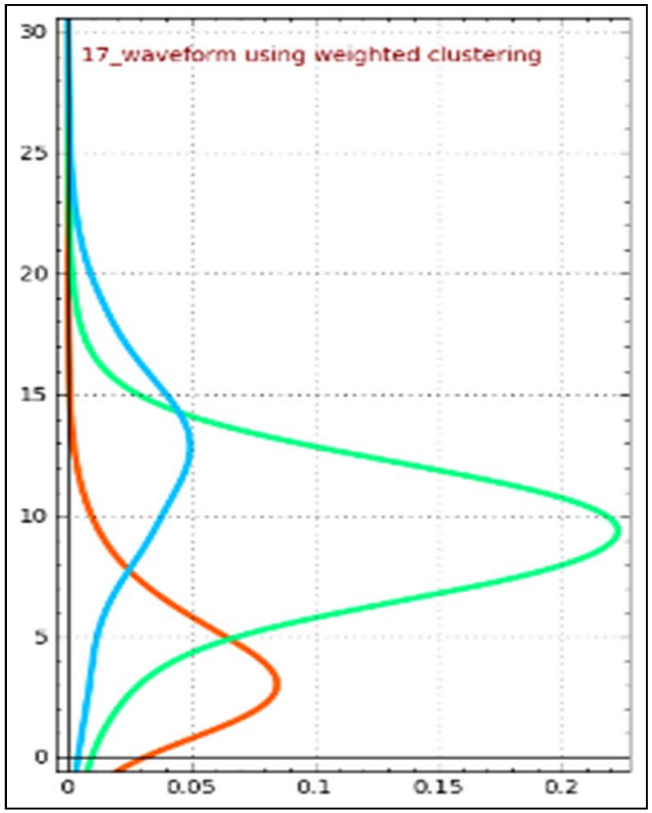
Recovery from fire

Mature pine

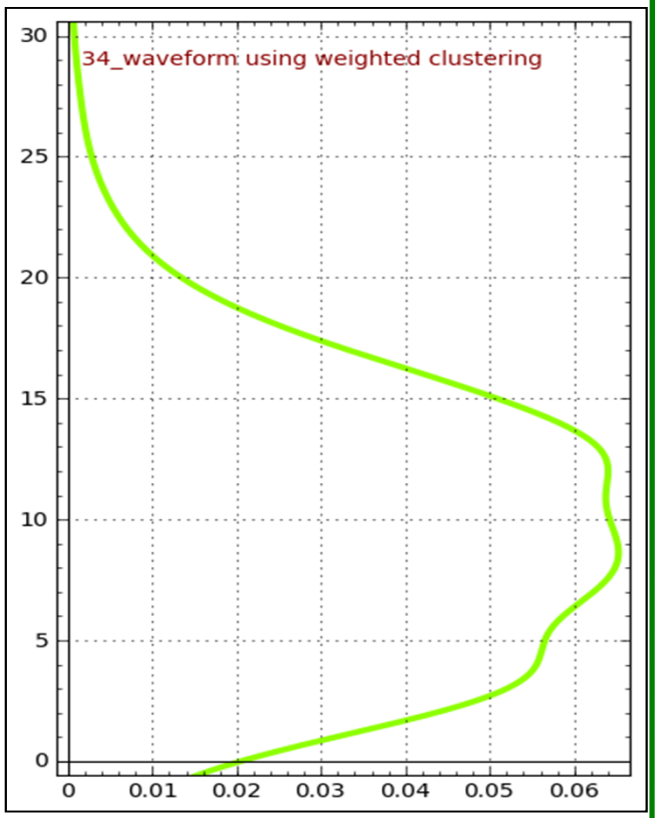
Interpretation of Landsat FPC, L-band HH and HV composites



Early Regrowth



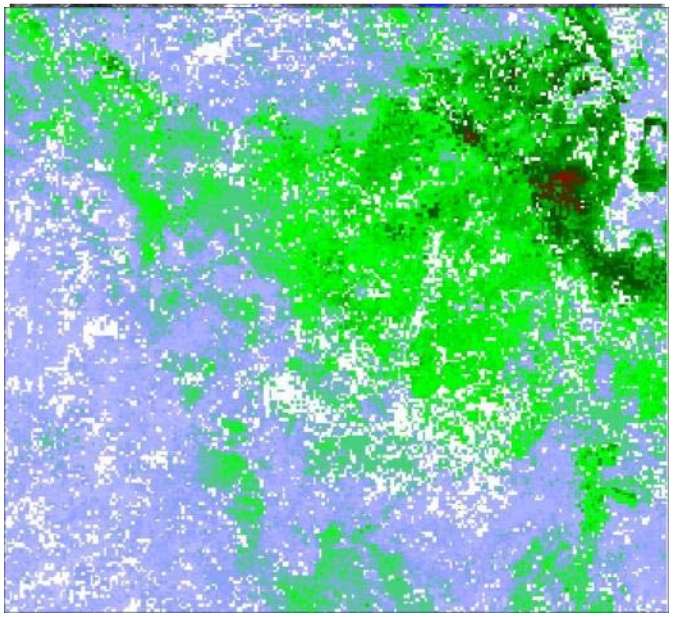
Recovery from fire



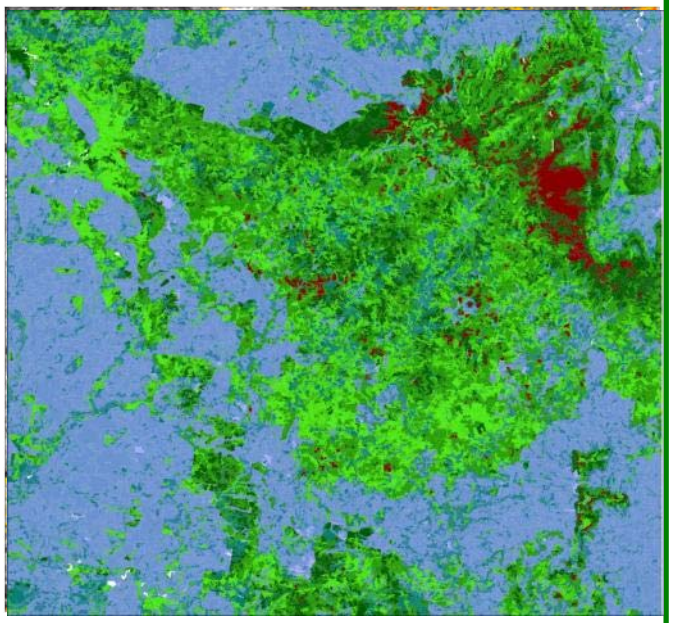
Mature pine

Interpretation of Landsat FPC, L-band HH and HV composites

Lefsky



Simard



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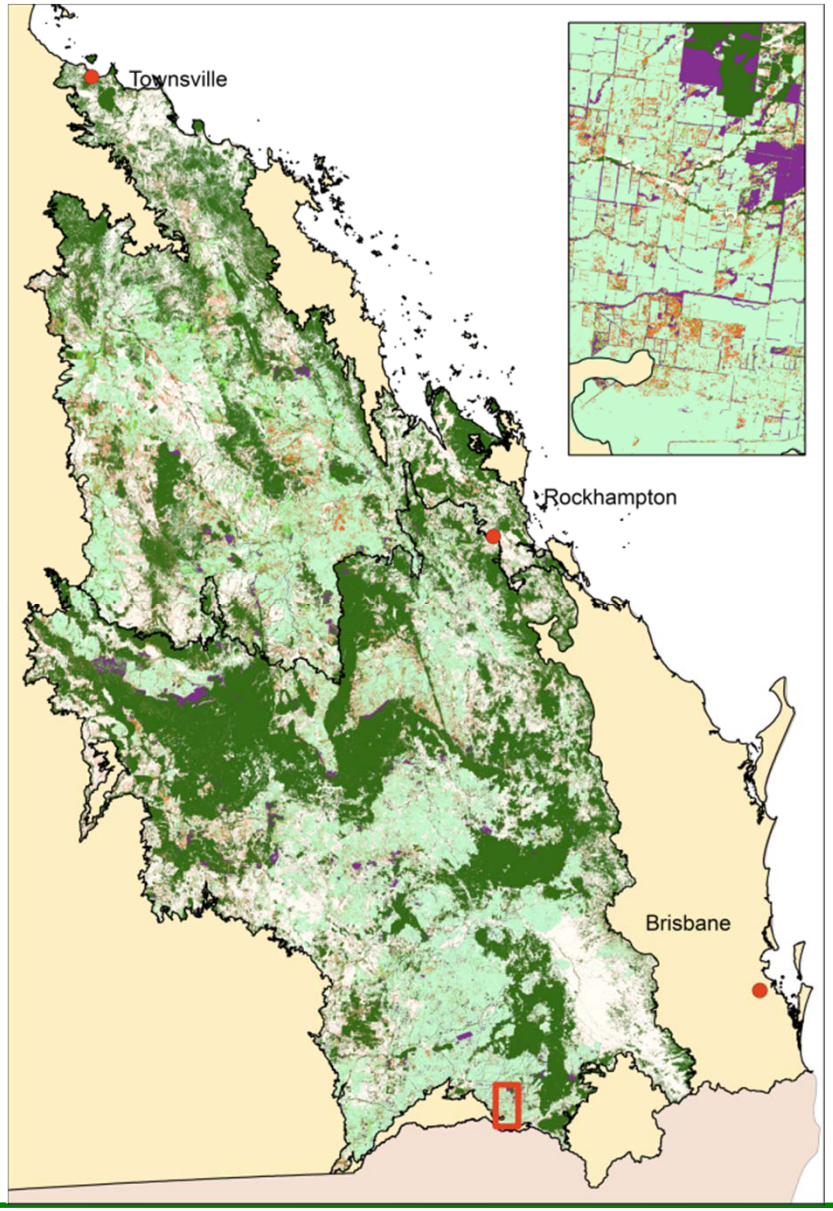
Comparison with other products (stand height)

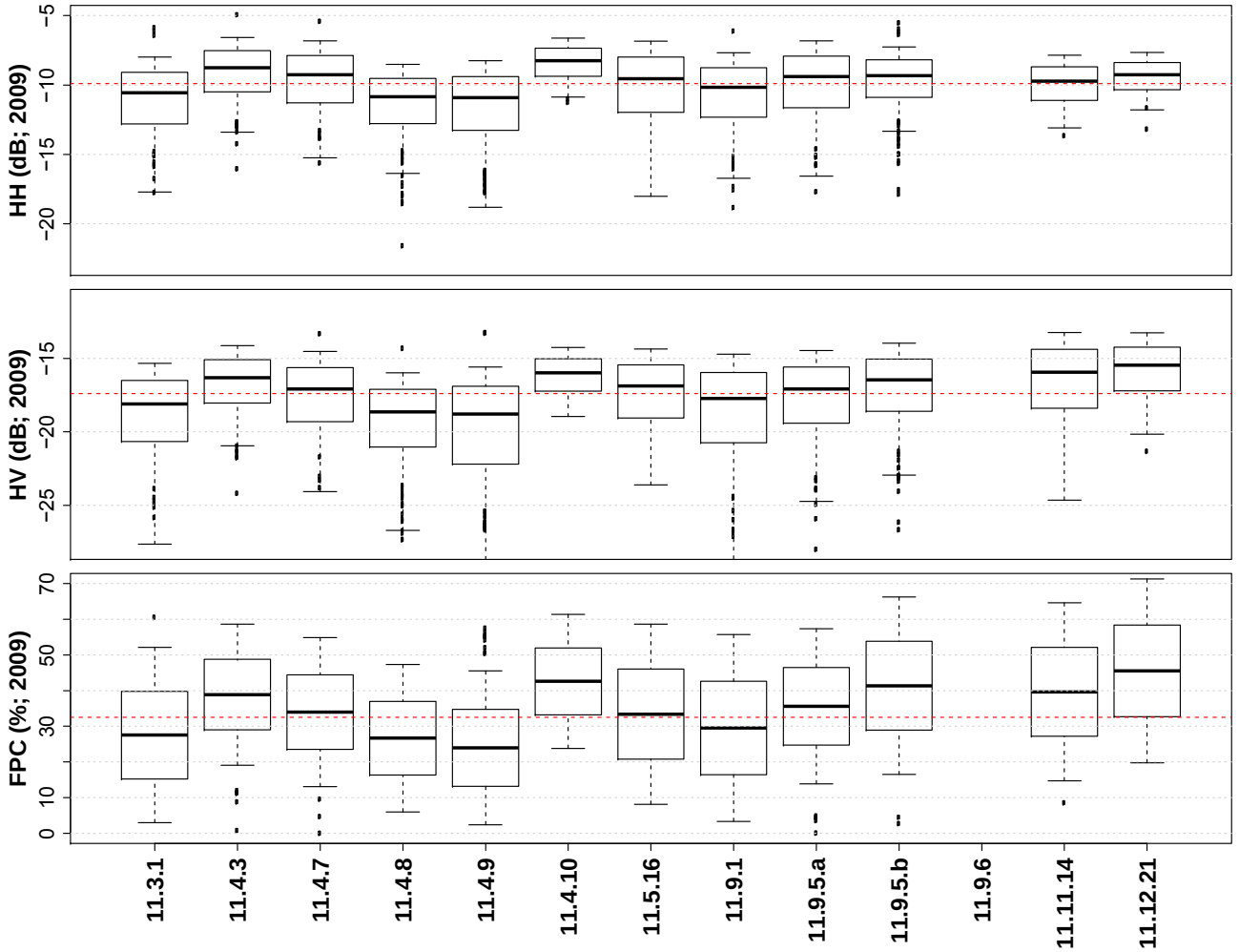


Regrowth stage mapping

Uses combination of ALOS PALSAR L-band HH, HV and FPC

Based on thresholds for discriminating non-forest, early and intermediate regrowth and relative distributions of data values for mature forest (by Regional Ecosystem)

Characteristics of Remnant Vegetation, Brigalow Belt Bioregion



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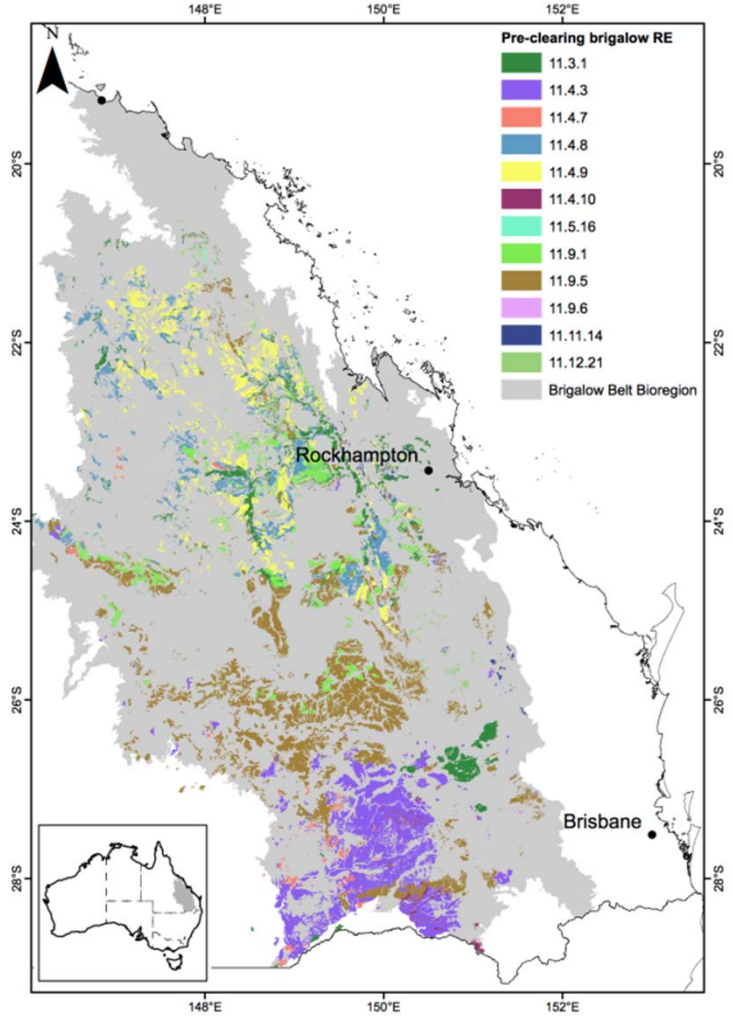
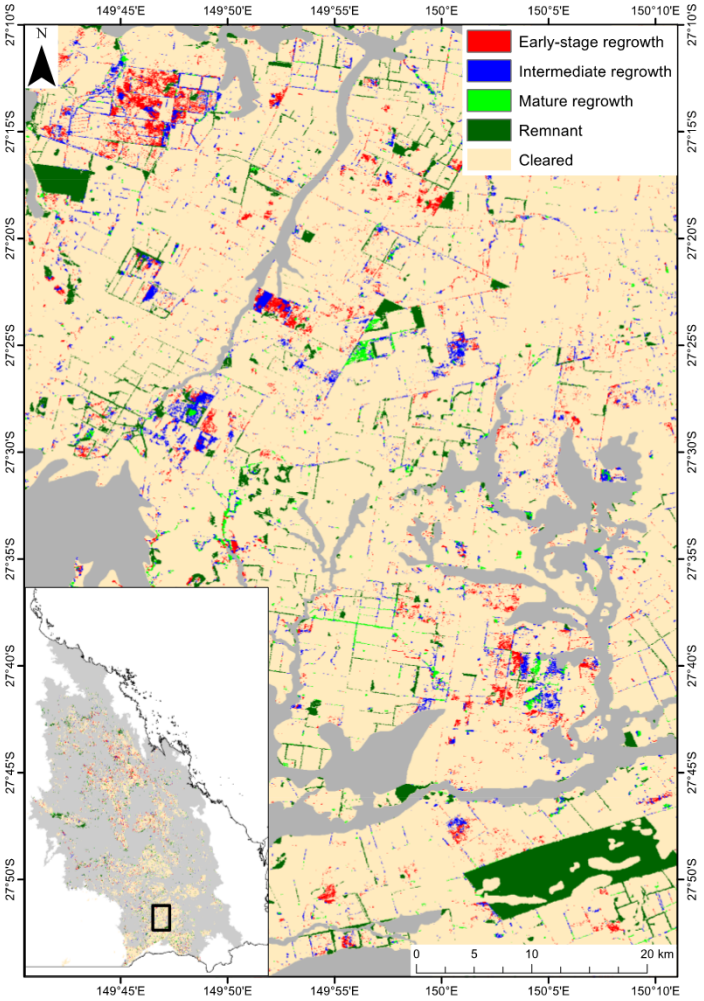
Forest Growth Stage Mapping, Brigalow Belt Bioregion



12 REs with Brigalow



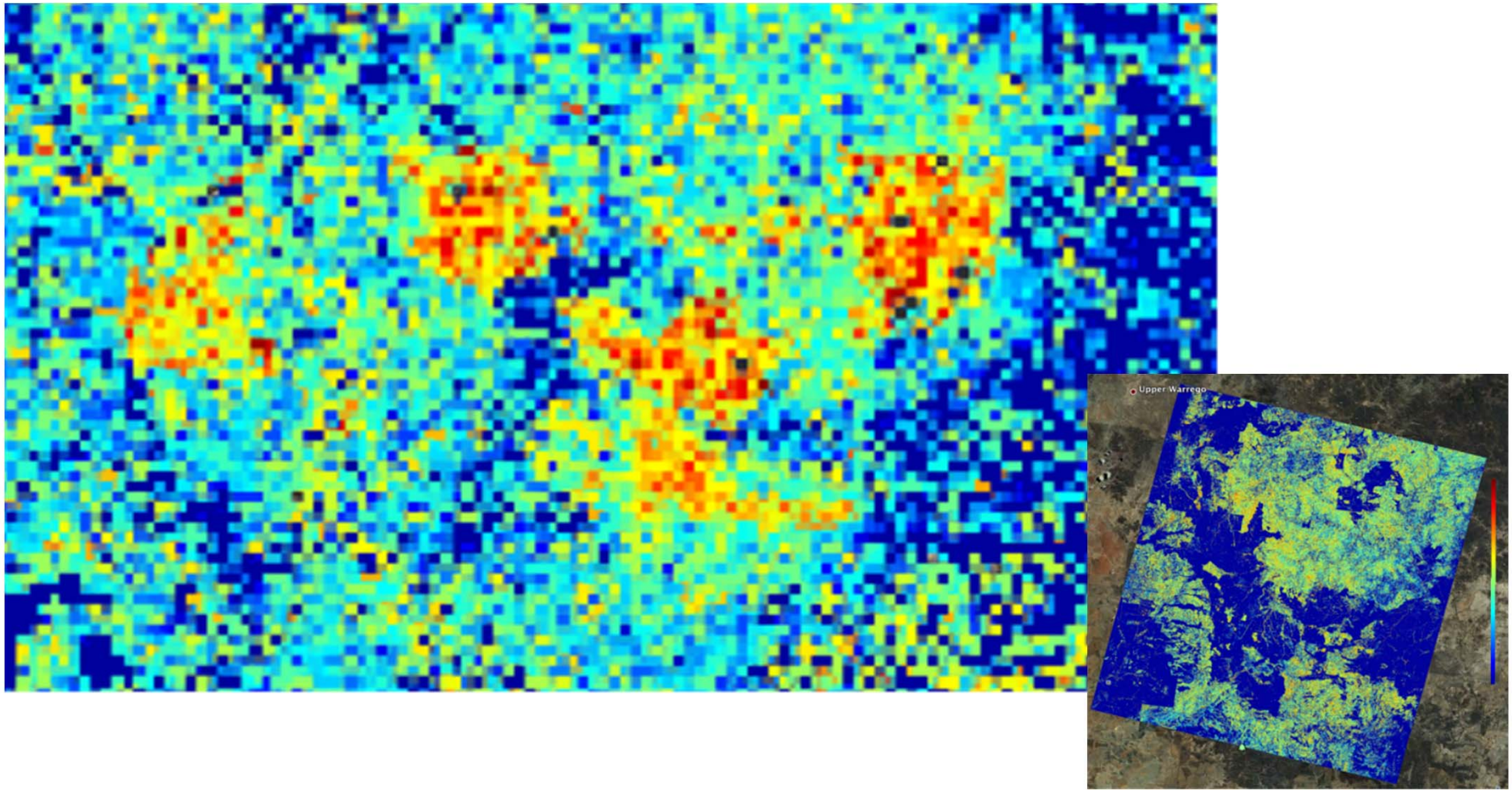
Regrowth classification

Regrowth Extent (Brigalow Belt Bioregion)

RE	Pre-clearing	Area; ha (% of pre-clearing extent)				Total (all stages)
		Early-stage	Intermediate	Mature	Remnant	
11.3.1	668,770	36,938 (5.5)	34,198 (5.1)	10,944 (1.6)	41,763 (6.2)	123,842 (10.5)
11.4.3	1,542,078	39,052 (2.5)	44,354 (2.9)	20,123 (1.3)	69,336 (4.5)	172,865 (14.6)
11.4.7	191,102	9,165 (4.8)	6,752 (3.5)	5,932 (3.1)	15,758 (8.2)	37,607 (3.2)
11.4.8	646,596	60,739 (9.4)	12,593 (1.9)	16,854 (2.6)	56,324 (8.7)	146,510 (12.4)
11.4.9	932,691	82,860 (8.9)	37,991 (4.1)	4,904 (0.5)	70,873 (7.6)	196,629 (16.6)
11.4.10	57,582	1,780 (3.1)	2,644 (4.6)	2,135 (3.7)	5,596 (9.7)	12,154 (1.0)
11.5.16	12,797	903 (7.1)	584 (4.6)	572 (4.5)	2,832 (22.1)	4,892 (0.4)
11.9.1	524,056	37,465 (7.1)	23,631 (4.5)	9,469 (1.8)	40,418 (7.7)	110,982 (9.4)
11.9.5	2,176,007	95,148 (4.4)	64,016 (2.9)	47,761 (2.2)	147,539 (6.8)	354,464 (30.0)
11.9.6	15,317	113 (0.7)	84 (0.6)	157 (1)	204 (1.3)	558 (<0.1)
11.11.14	34,609	1,142 (3.3)	1,927 (5.6)	1,502 (4.3)	3,794 (11)	8,364 (0.7)
11.12.21	71,350	3,169 (4.4)	1,777 (2.5)	3,310 (4.6)	6,063 (8.5)	14,318 (1.2)
Total (all REs)	6,872,955	368,473	230,551 (3.4)	123,662 (1.8)	460,499 (6.7)	1,183,185
Percentage ([1],[2])		5.4 31.1	3.4 19.5	1.8 10.5	6.7 38.9	

[1]Of total area of the 12 REs; [2]Of area of forest within the 12 REs

Change Detection (Example from Injune)



Yang et al. (2012). Observation of vegetation vertical structure and disturbance using L-band InSAR over the Injune region in Australia. Remote Sensing of Environment, K&C Special Issue.

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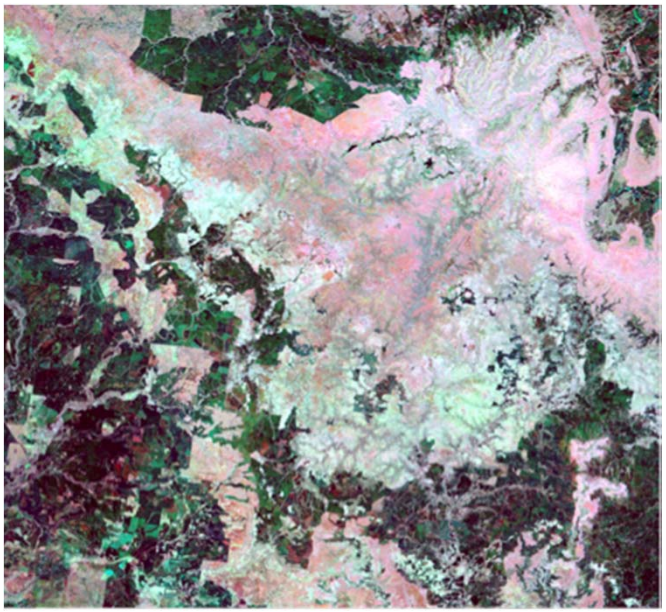
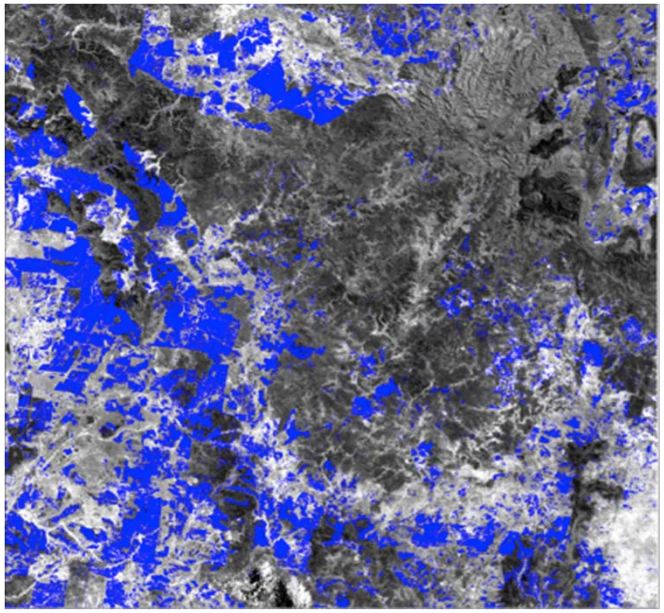
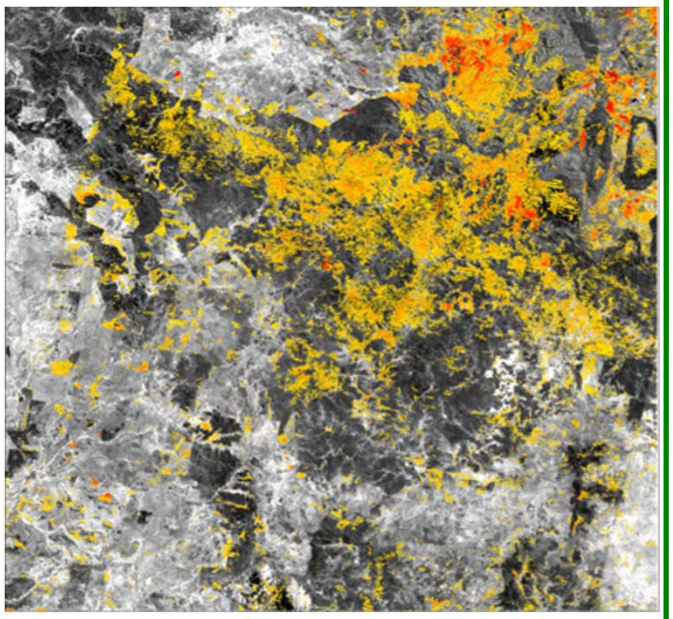


Landsat FPC, ALOS PALSAR
L-band HH and HV (RGB)



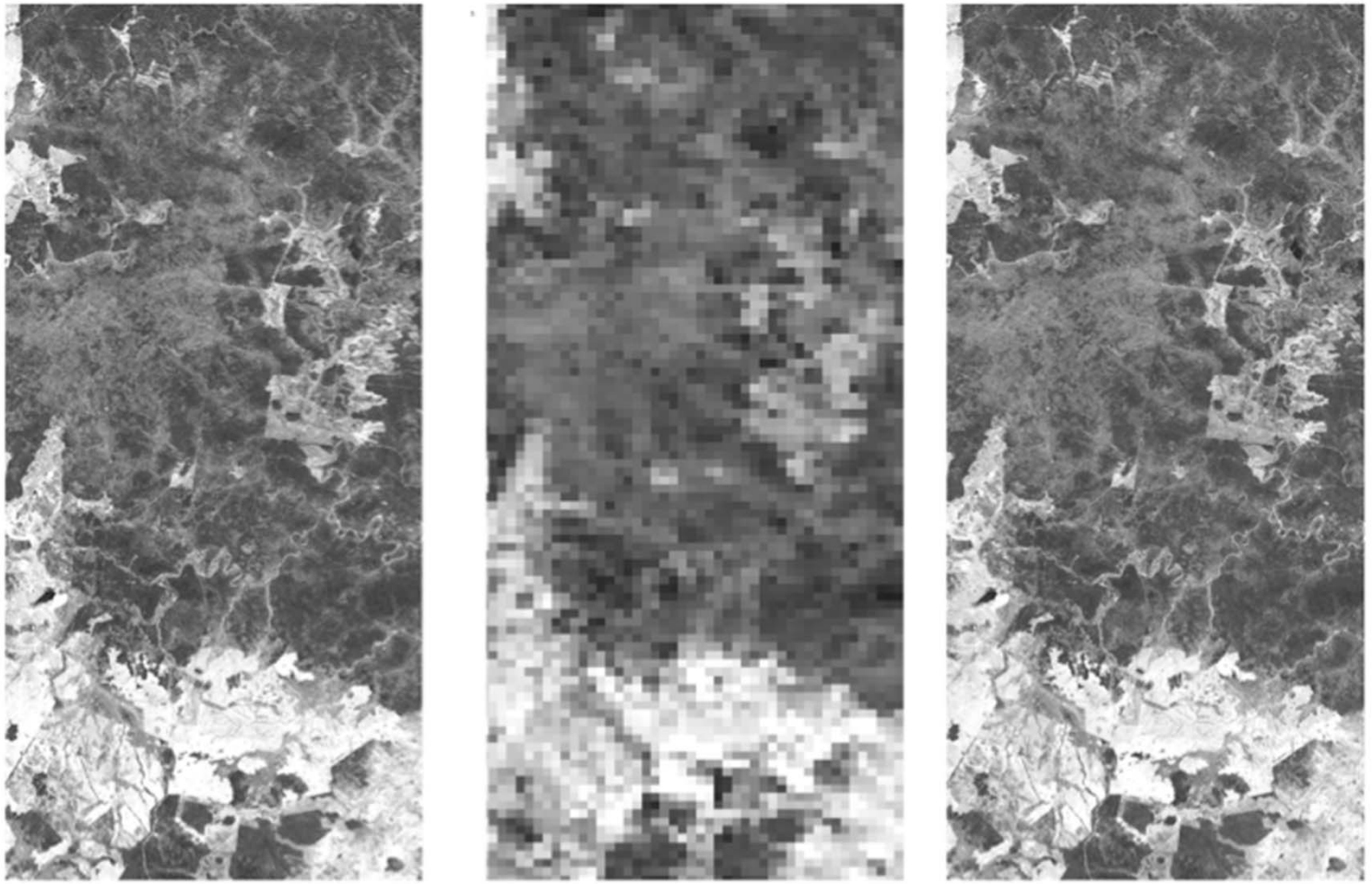
Total area cleared



Fire history

- Time-series of Landsat sensor data used by Queensland Statewide Land Cover and Trees (SLATS) projects to produce annual statewide estimates of woody vegetation extent.
- Linked to detailed mapping (e.g., from field and aerial photography) of regional ecosystems to establish status (.e., clearance, remnant vegetation).
- Hyper-temporal analysis of Landsat sensor data used to establish dynamics associated with human-induced and natural events and processes.

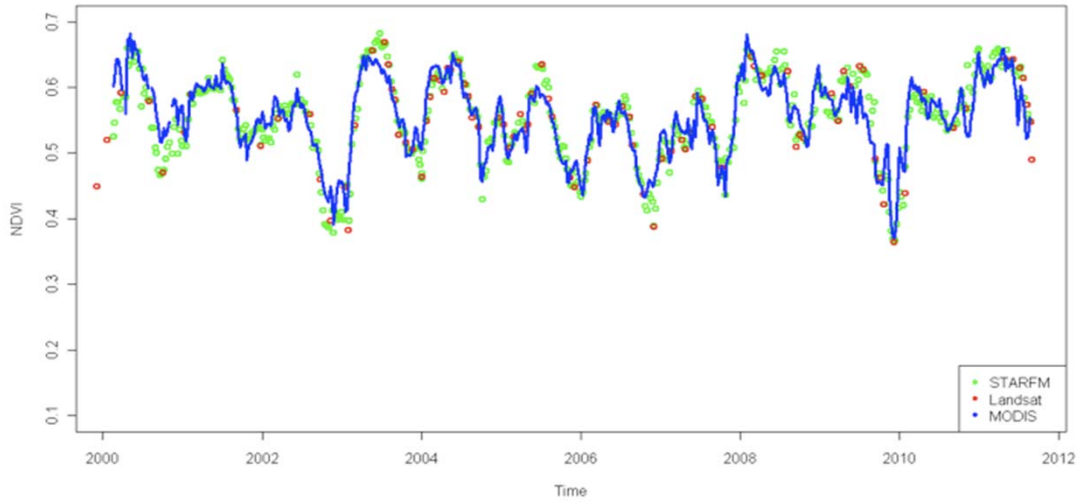
Change Detection using Landsat and MODIS-simulated Landsat

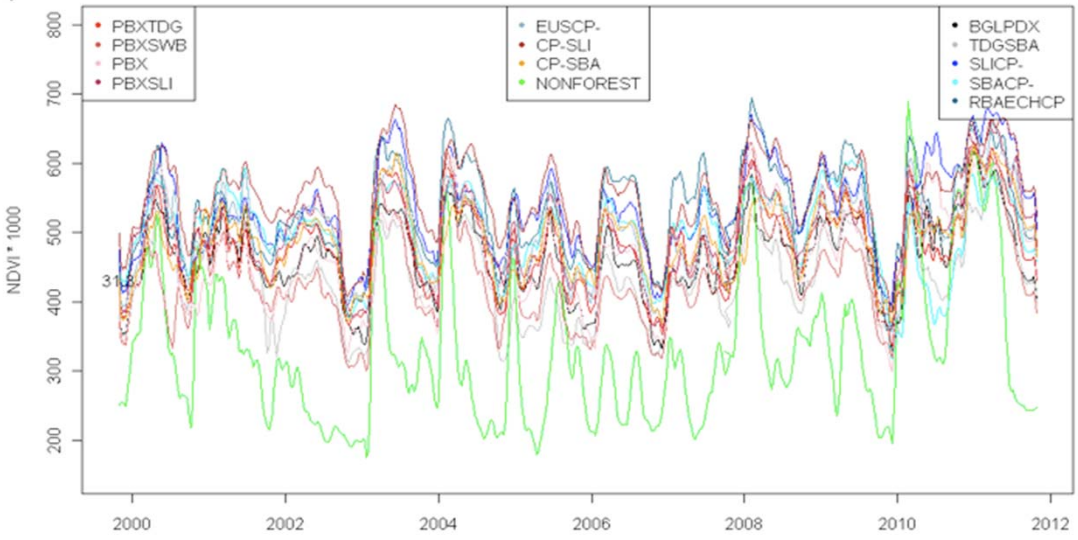


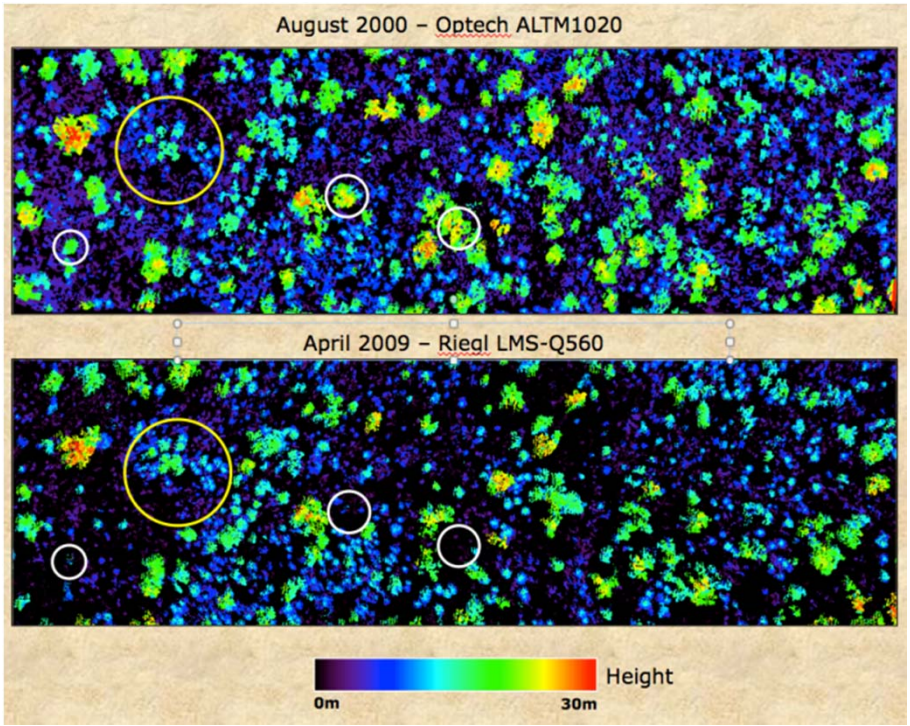
a) Landsat 5 - 20110707 b) MODIS - 20110712 c) STARFM - 20110712

Schmidt et al. (2012). Multi-resolution time series imagery for forest disturbance and regrowth monitoring in Queensland, Australia. Remote Sensing of Environment (in review)

Change Detection







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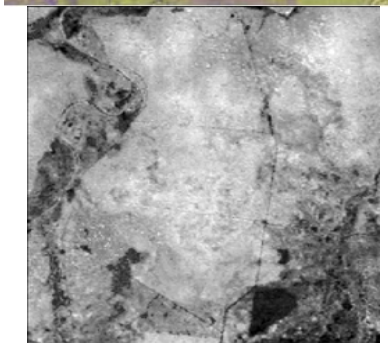
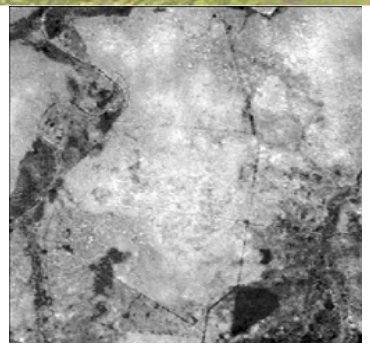
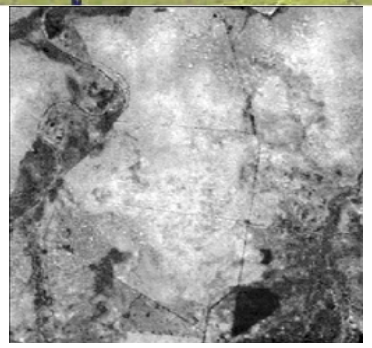


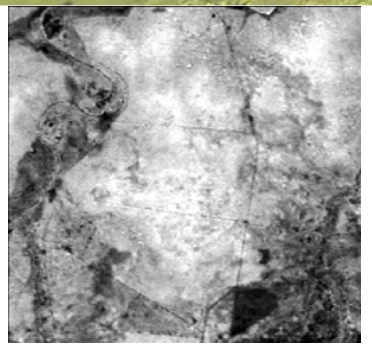
5th Aug 2007



13th Aug 2007



21st Aug 2007



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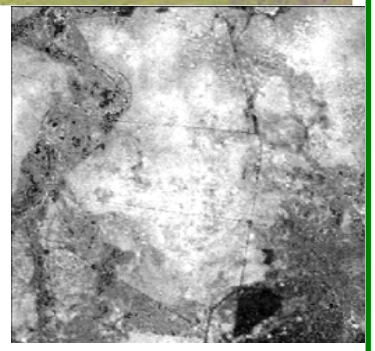
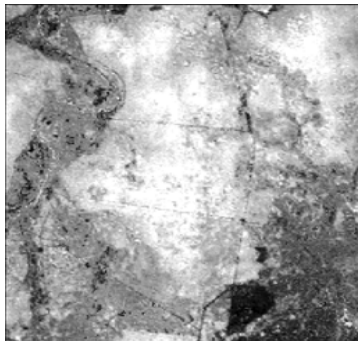


6th Sep 2007



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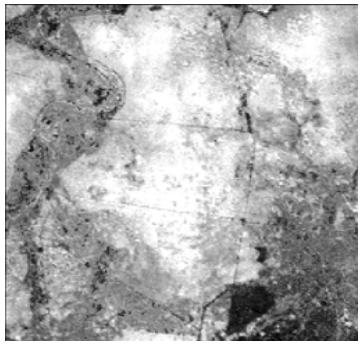

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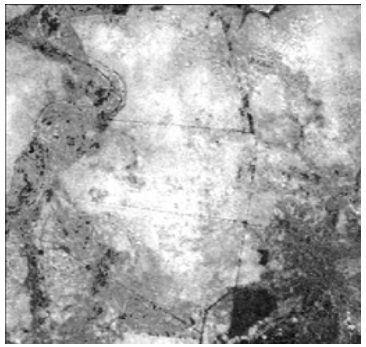
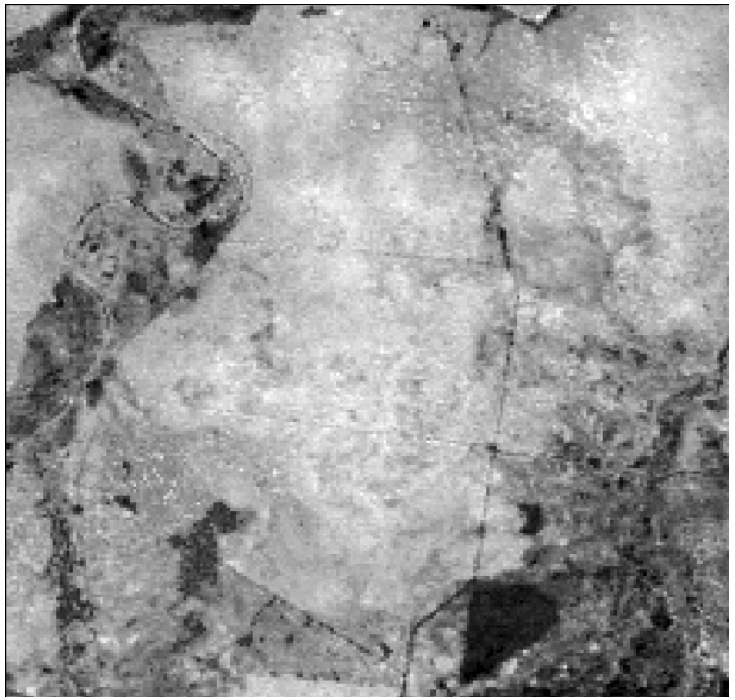


30th Sep 2007

Hyper-temporal Landsat FPC (actual, simulated)



5th Aug 2007

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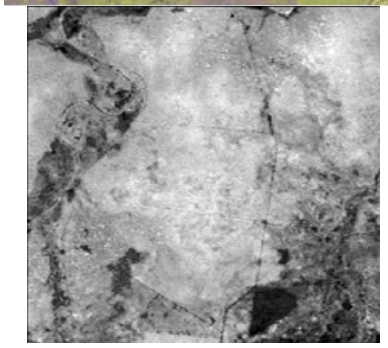

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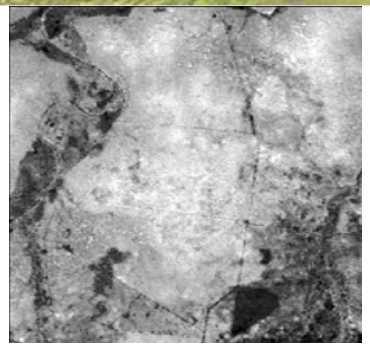

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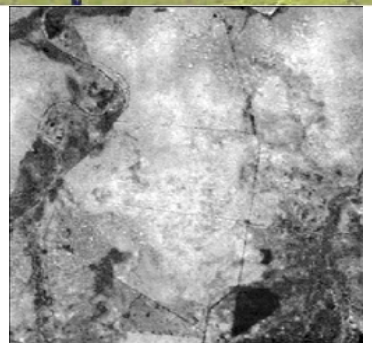

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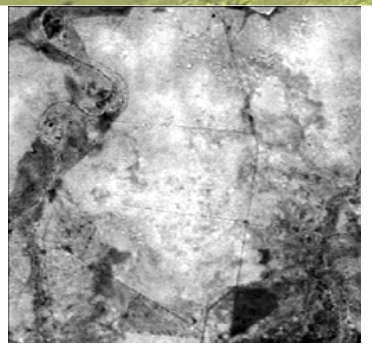

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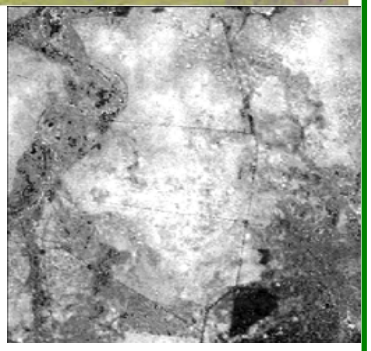

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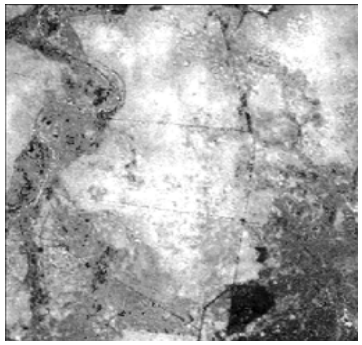

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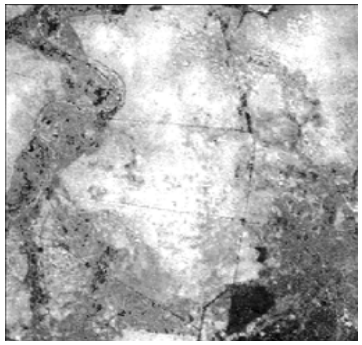

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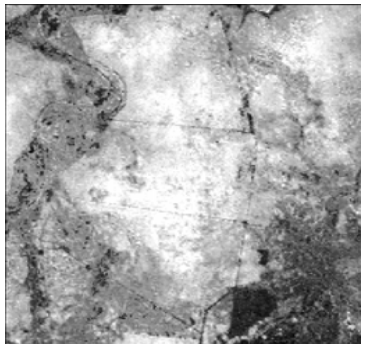

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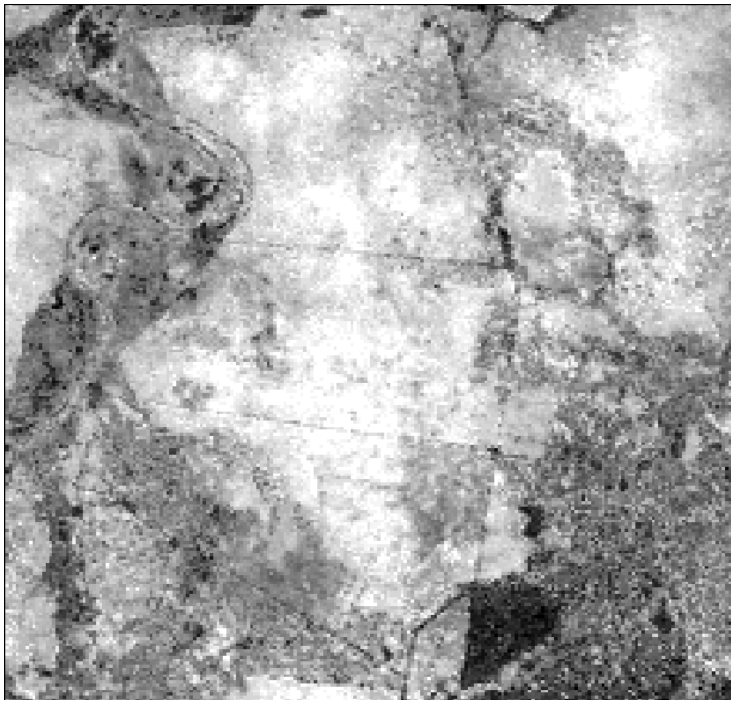

5th Aug 2007

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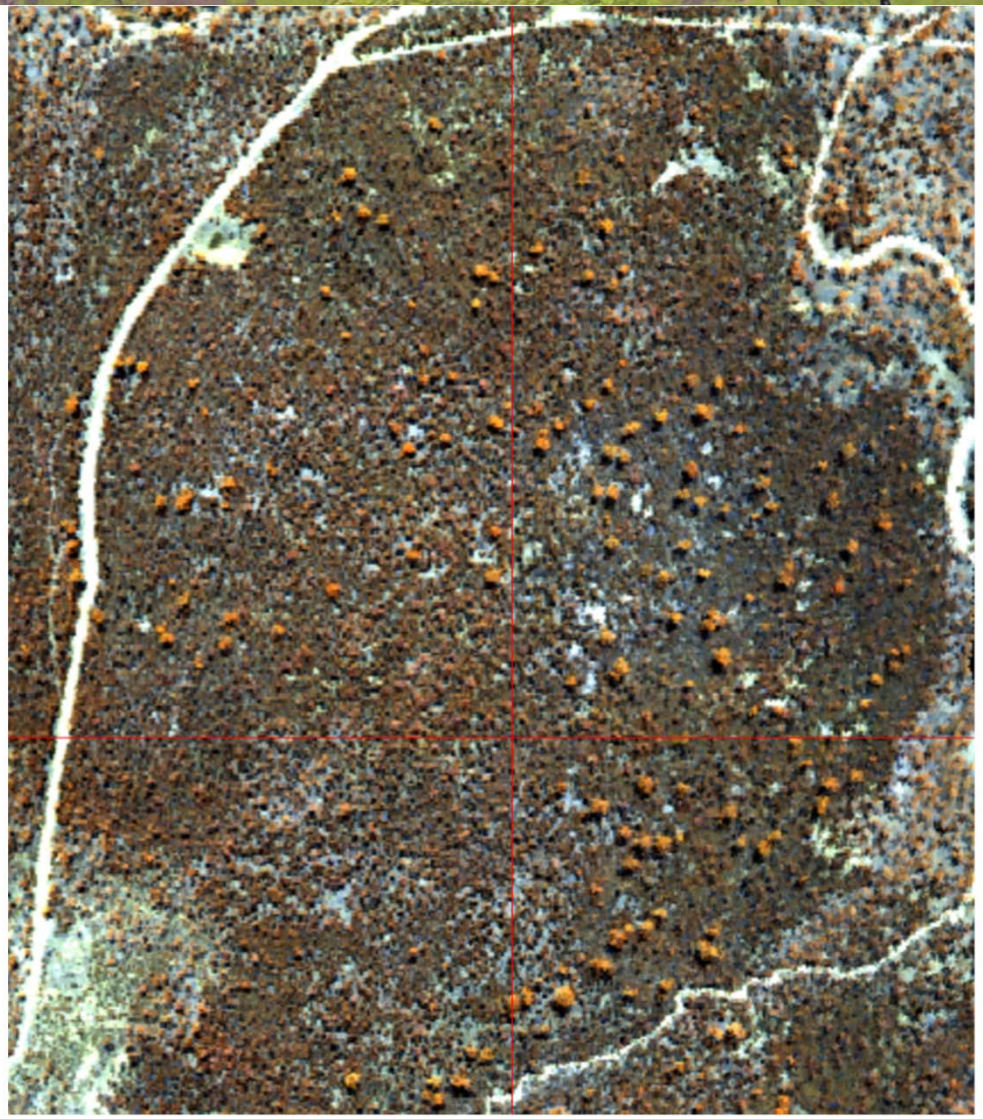
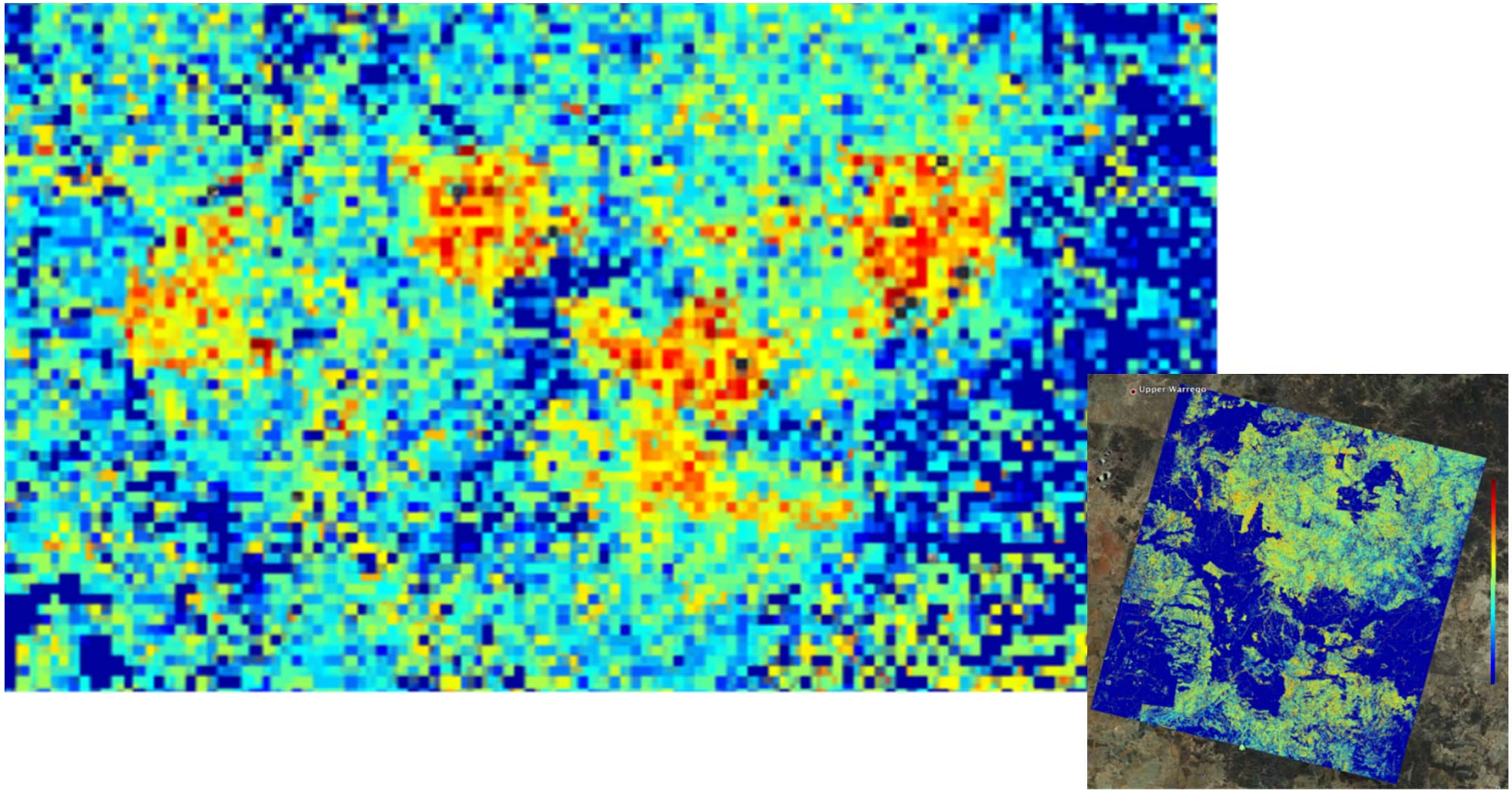


Hyperspectral HYMAP (2000)

Worldview 2 (2010)

Change Detection (Example from Injune)



Yang et al. (2012). Observation of vegetation vertical structure and disturbance using L-band InSAR over the Injune region in Australia. Remote Sensing of Environment, K&C Special Issue.

Support to JAXA's global forest mapping efforts: Deliverables

- Provision of forest/non-forest data and mapping for States then Australia (based on fractional cover)
  - Woodlands as well as forests
    - Definitions based on cover and height (ICESat?)
  - Refinement to forest/non-forest maps through integration of L-band SAR data
- Provision of biomass estimates and mapping for States then Australia
  - Open source segmentation algorithm
  - ALOS PALSAR data alone or in combination with ICESAT and Landsat fractional cover.
- Products developed to align with JAXA maps.
- Collaborative activities and exchange visits
- Assistance with algorithm development.

- Acknowledgements
  - JAXA/RESTEC
  - QDERM
    - SLATS
    - Queensland Herbarium
  - UNSW
  - Definiens AG/Trimble
  - University of Massachusetts
  - Tropical Research Institute, Portugal