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An international science collaboration led by JAXA

K&C Phase 3

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

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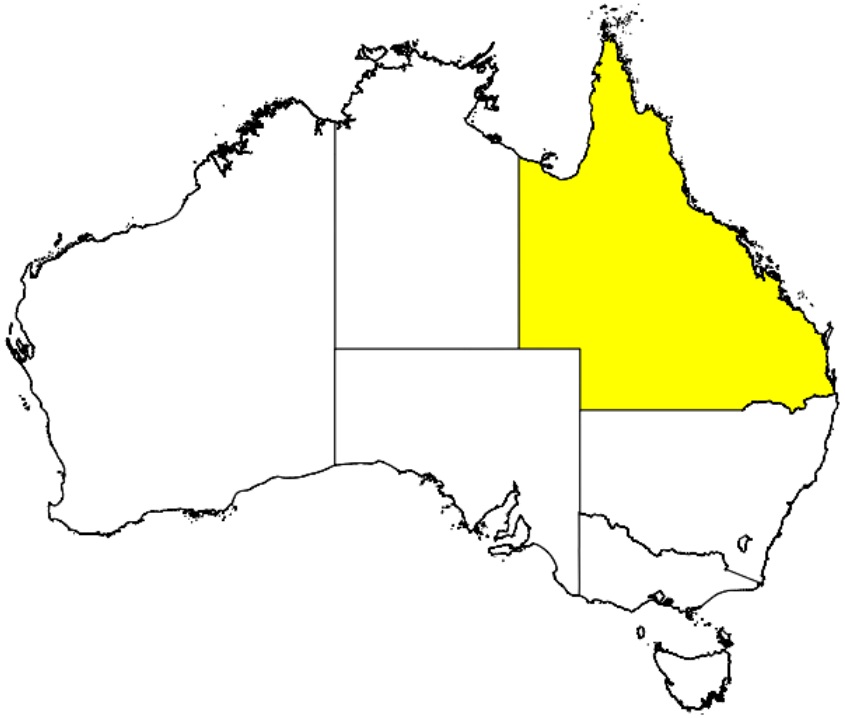
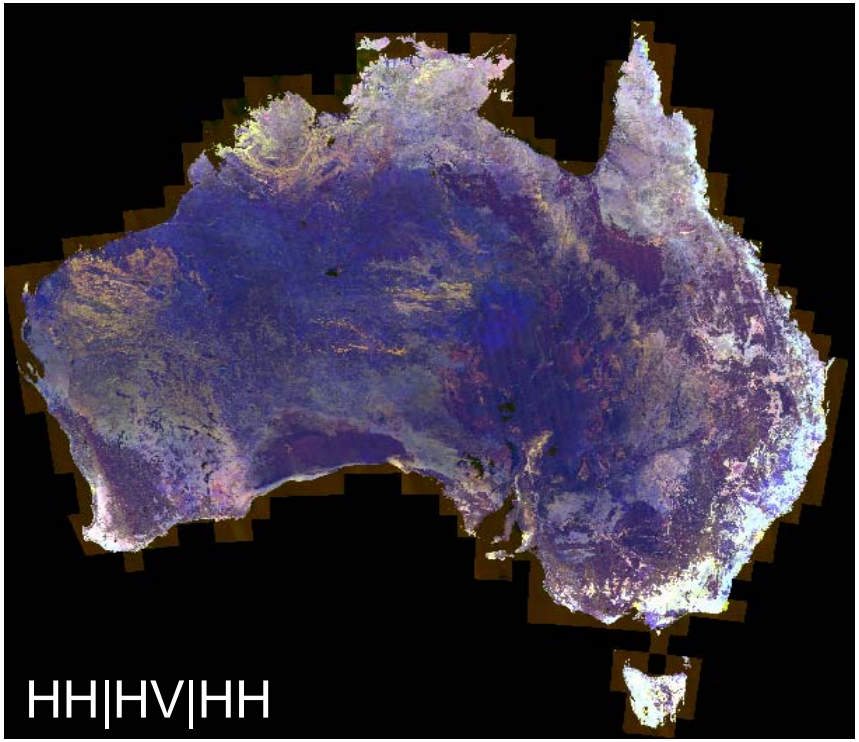
Presentation Outline

- **JAXA project area, objectives, schedule and deliverables**
- Australian validation data collation
- Persistent Green Vegetation from Landsat
- Large area segmentation of PALSAR/Landsat products
- Regional forest regrowth extent mapping development
- Australian vertical apparent foliage profile product development
- Australian above-ground biomass product development
- Case studies of mapping and modelling biomass change

Project area

- Focus initially on Queensland, Australia
  - Injune Study Site key case study
- Extension to New South Wales, Victoria and the Northern Territory (JRSRP)
- Subsequent application across Australia





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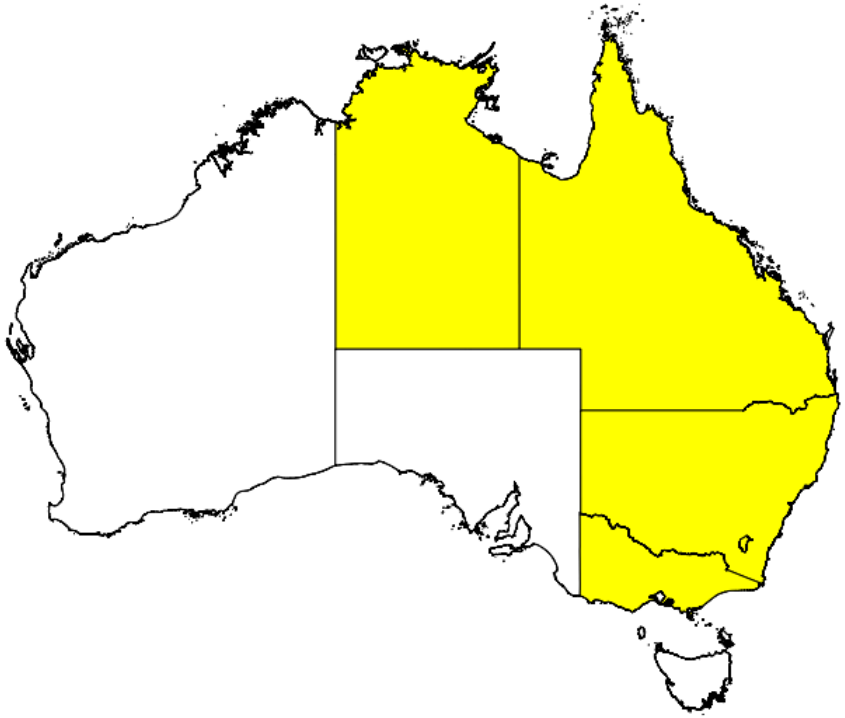

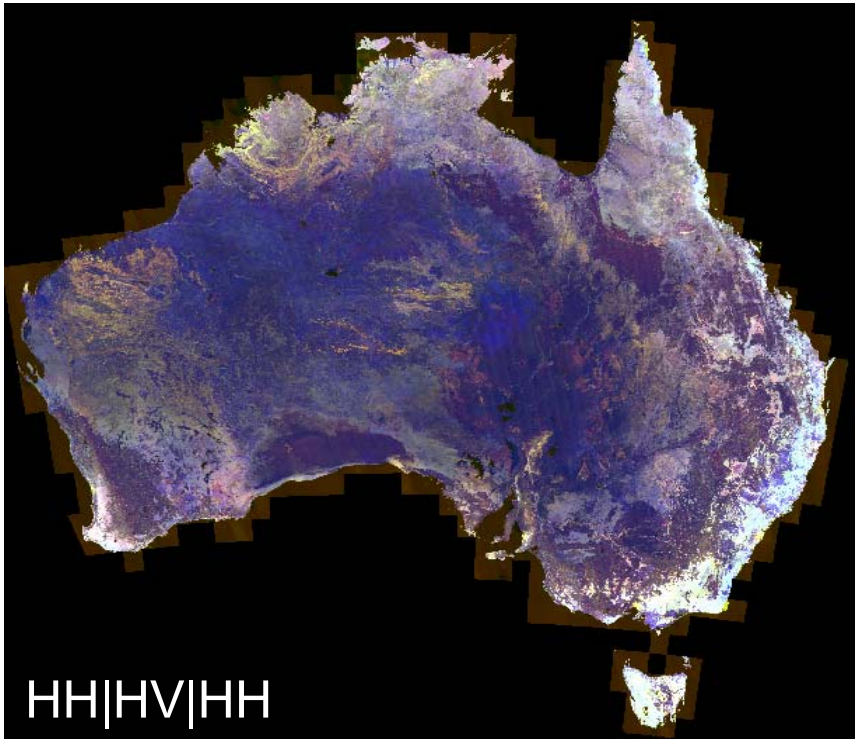

Project objectives

Objective: To provide R&D support to the generation of JAXA's global forest/non-forest and above ground biomass maps

- Advance development and validation of algorithms for Australian conditions
- Support quantification of forest/non-forest extent and change, biomass (carbon), biomass change and associated carbon losses and gains
- Supports *K&C thematic drivers*
  - **C**arbon cycle science – deliverables are input to carbon data assimilation schemes (CSIRO) and carbon offsets research
  - Environmental **C**onservation – regional mapping at a scale relevant to land management and State Government vegetation management policy

Project schedule (revised)

- December, 2013
  - 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 1.0)
  - Generation of vegetation height map for Australia
- March, 2014
  - Generation of Version 2.0 of a 30 m spatial resolution map of AGB for eastern and northern Australia
- April, 2015
  - Generation of above-ground biomass and forest change maps
  - Extension to all of Australia

Support to JAXA's global forest mapping effort

- Supports JAXA's global forest mapping effort in Australia
  - Improved local calibration and validation of mapping, particularly for woodlands and savannas
  - Application of datasets and access to research products through national collaborative research programs and infrastructure such as TERN

- Collation and standardisation of ground and airborne datasets that will be shared with JAXA
  - Field observations of forest extent and AGB ("biomass library")
  - Ground and airborne lidar data archives

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Deliverables

Project deliverables and anticipated results:

- Baseline vegetation maps for 2009
  - Regional forest regrowth extent mapping (Brigalow Belt Bioregion complete)
  - Vertical foliage profile product for Australia (in progress)
  - Above-ground biomass for Australia (in progress)
- Validation of JAXA K&C mapping products

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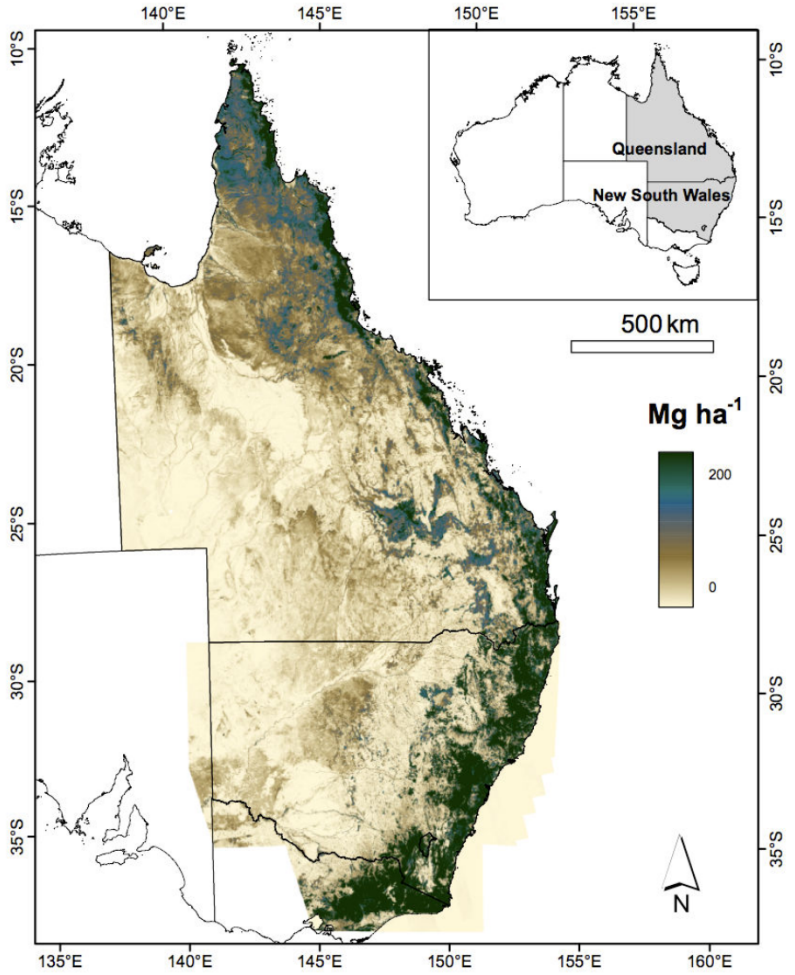

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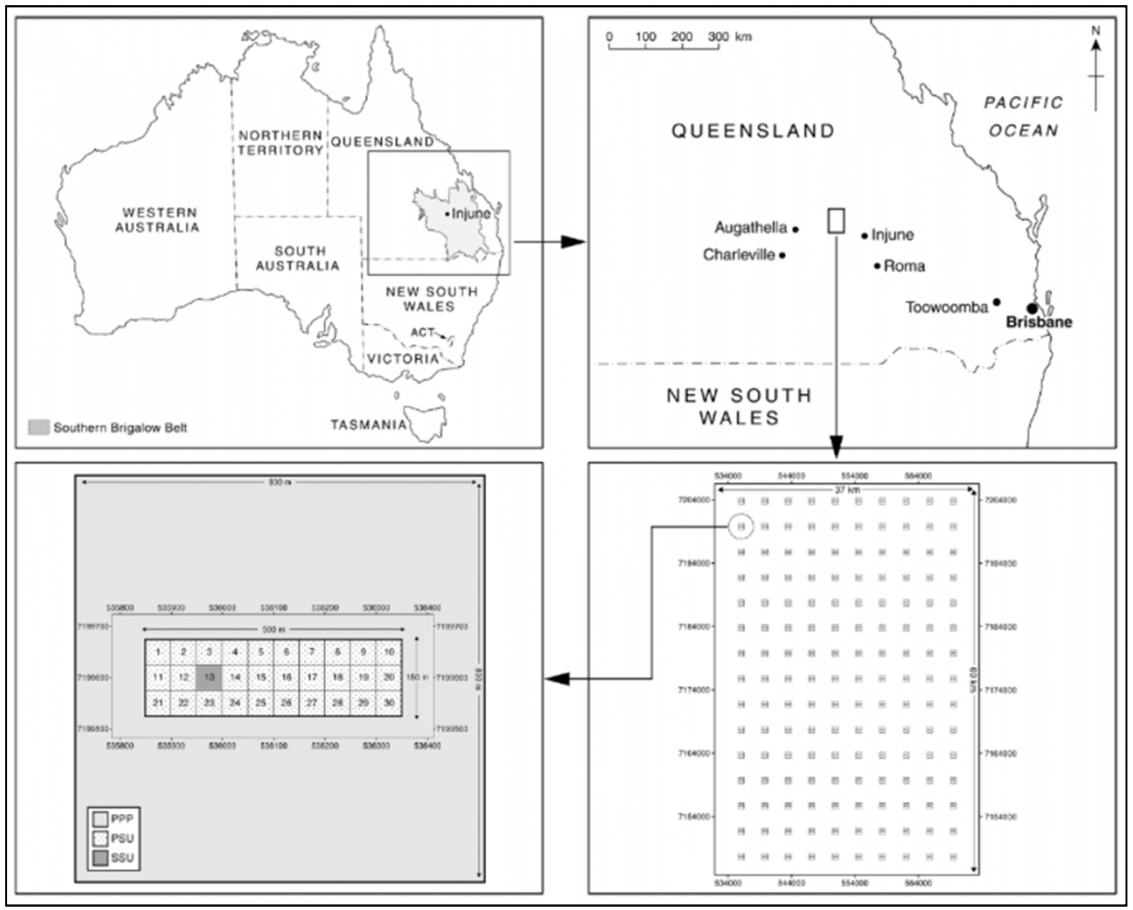
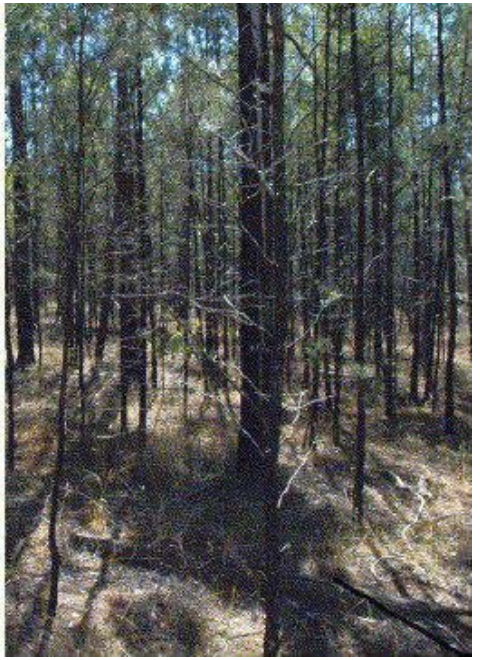
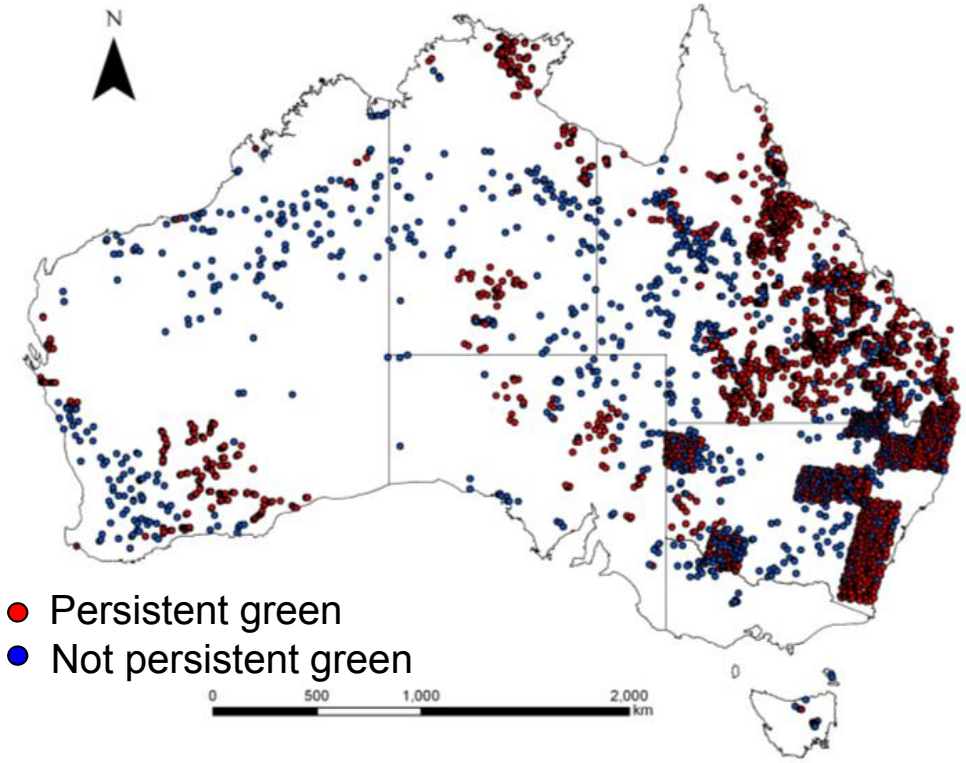
The Injune Landscape Collaborative Project





Forest and woodland extent observations

- Approximately 5100 sites of which 3800 are persistent green

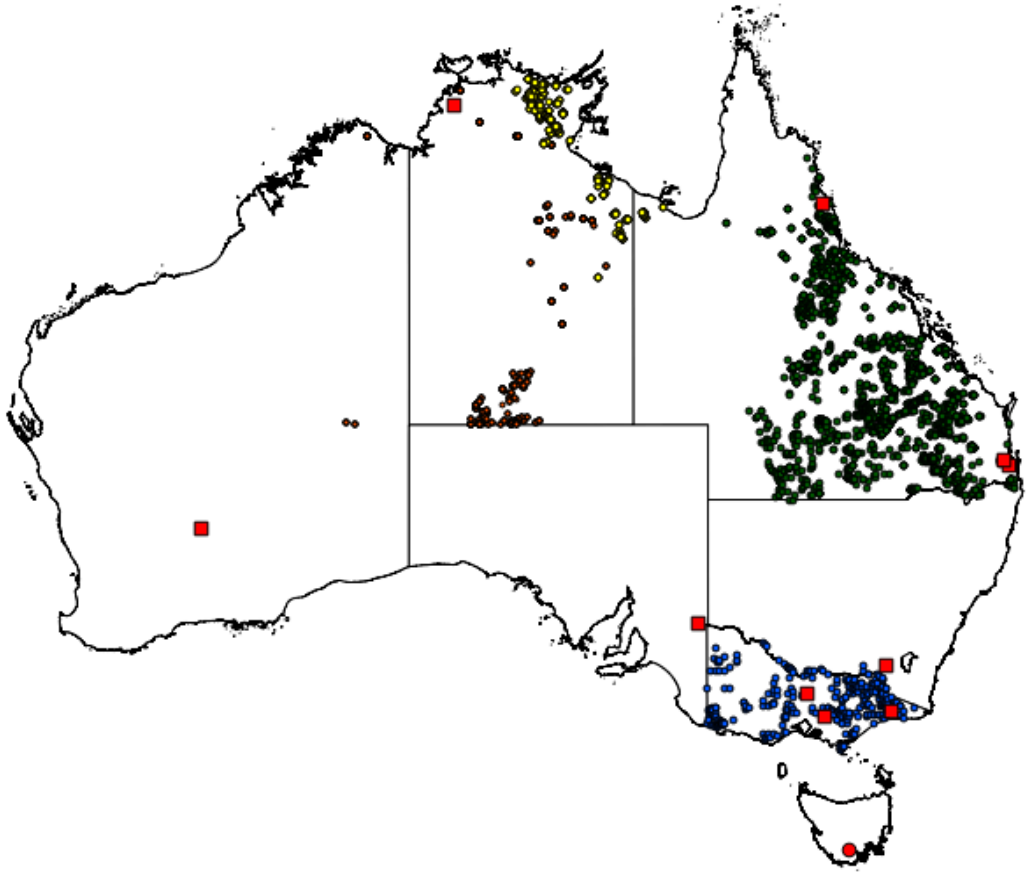


Source	Description
Queensland DSITIA	Fractional cover field sites
ABARES	Fractional cover field sites
NSW OEH	Image-interpretation of woody/not-woody vegetation cover
NT Bushfires	DBH field sites
NT NRETAS	Fractional-cover field sites
ACRIS	Locations of low-foliage scrub
WA	woody-vegetation sampling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

Above-ground biomass library

Collation of plot-based measurements of stem DBH ongoing:

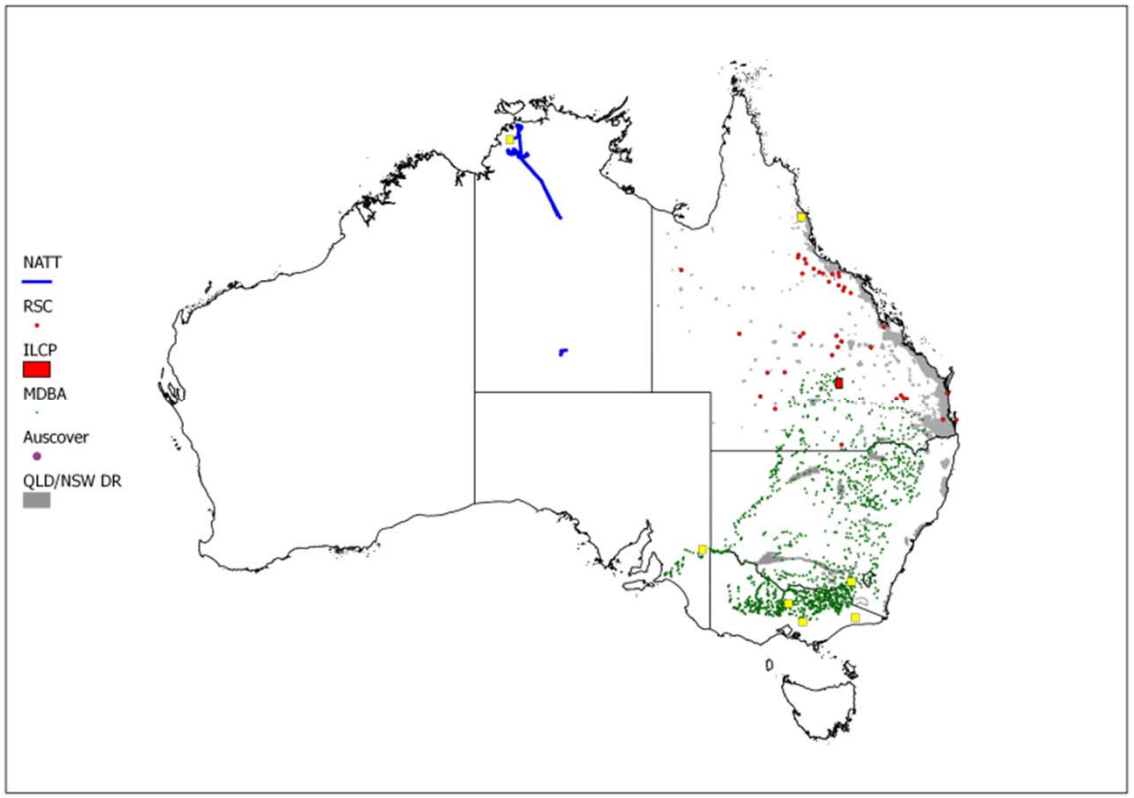
- Extension of K&C Phase 2 biomass library
- >2000 sites



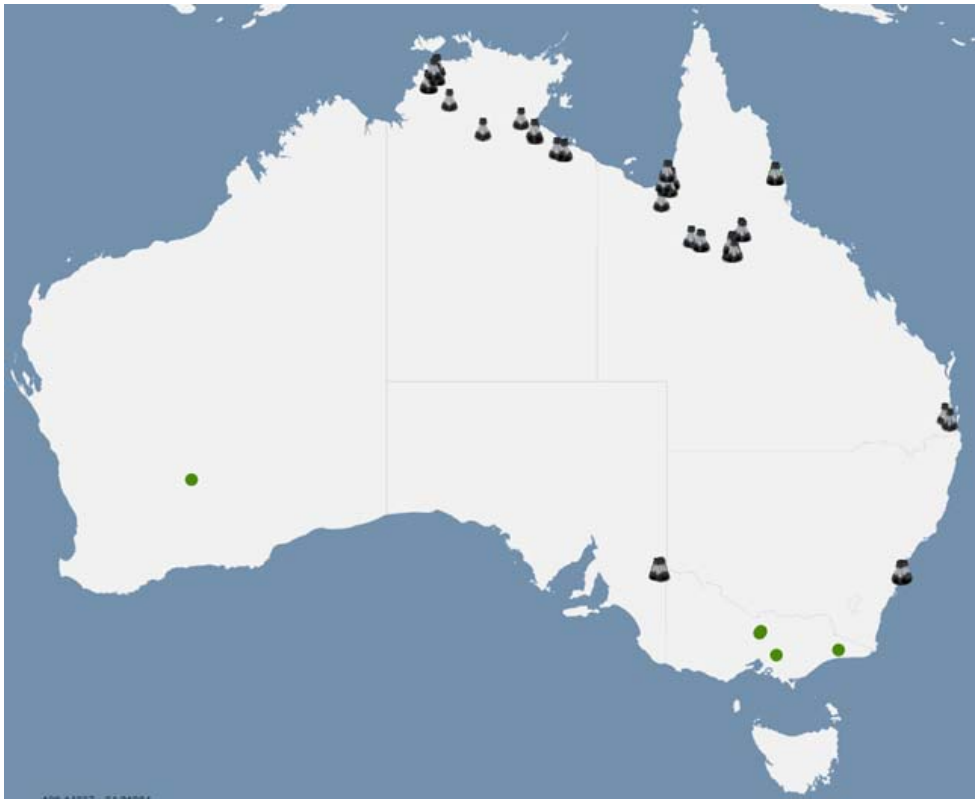
Source	Description
Queensland Herbarium	Carbon Accumulation Through Ecosystem Recovery (CATER) project
Victoria DSE	Large and Small Tree Plots
James Cook University	Robson Creek 25 ha stem inventory
TERN Auscover	Supersite field plots
Northern Territory Government	Basal area field sites
NT Bushfires	DBH field sites
Forestry Tasmania	Warra 1 ha stem inventory

Lidar data acquisition and collation

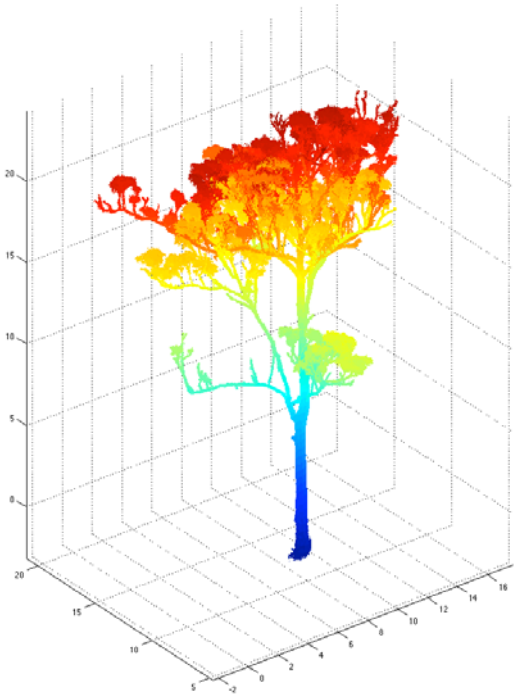
Airborne

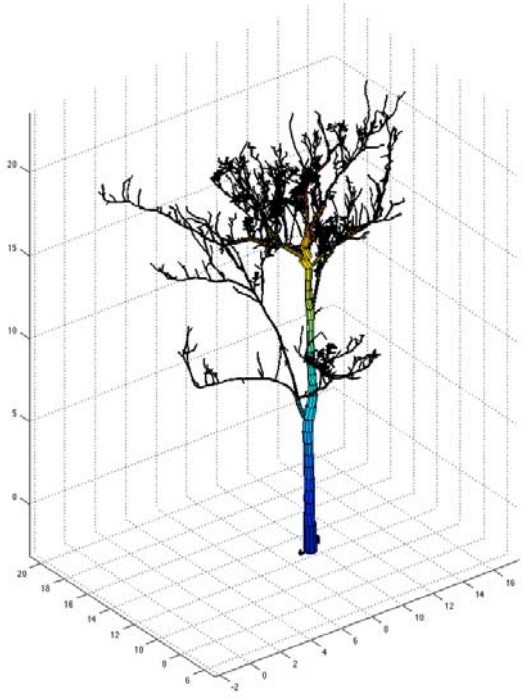


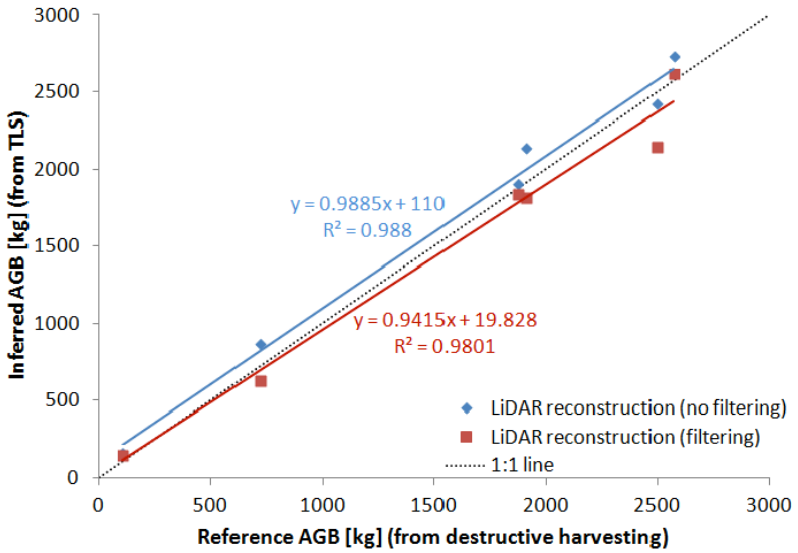
Ground



Ground-based lidar







	Field	Riegl
DBH (cm)	61.9	60.85
Height (m)	28.2	27.28
Volume (m^3)	-	6.4022
Biomass (kg)	3194.93[1]	4673.61

[1]Allometric Williams *et al*. (2005). SG=0.73.

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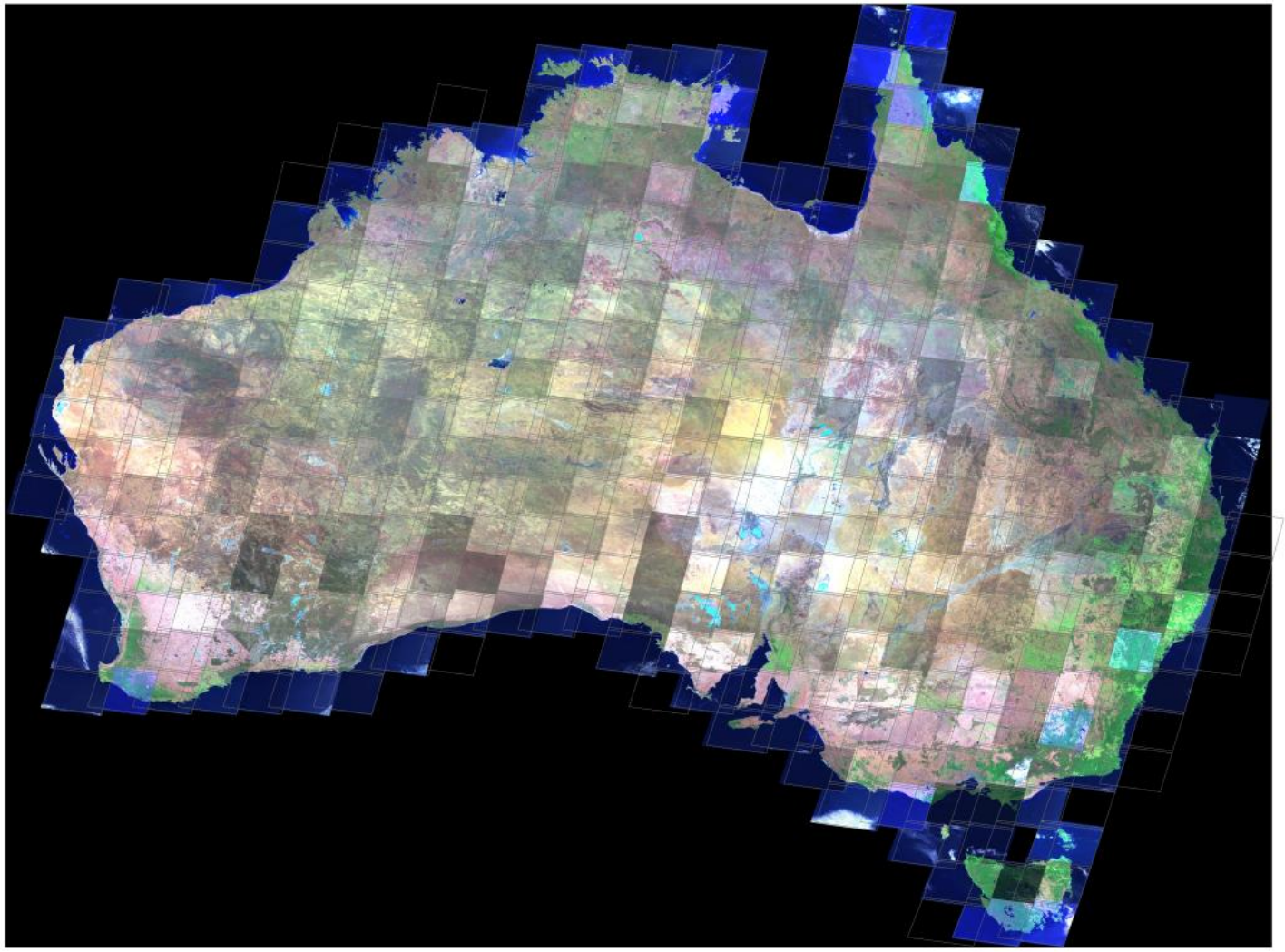
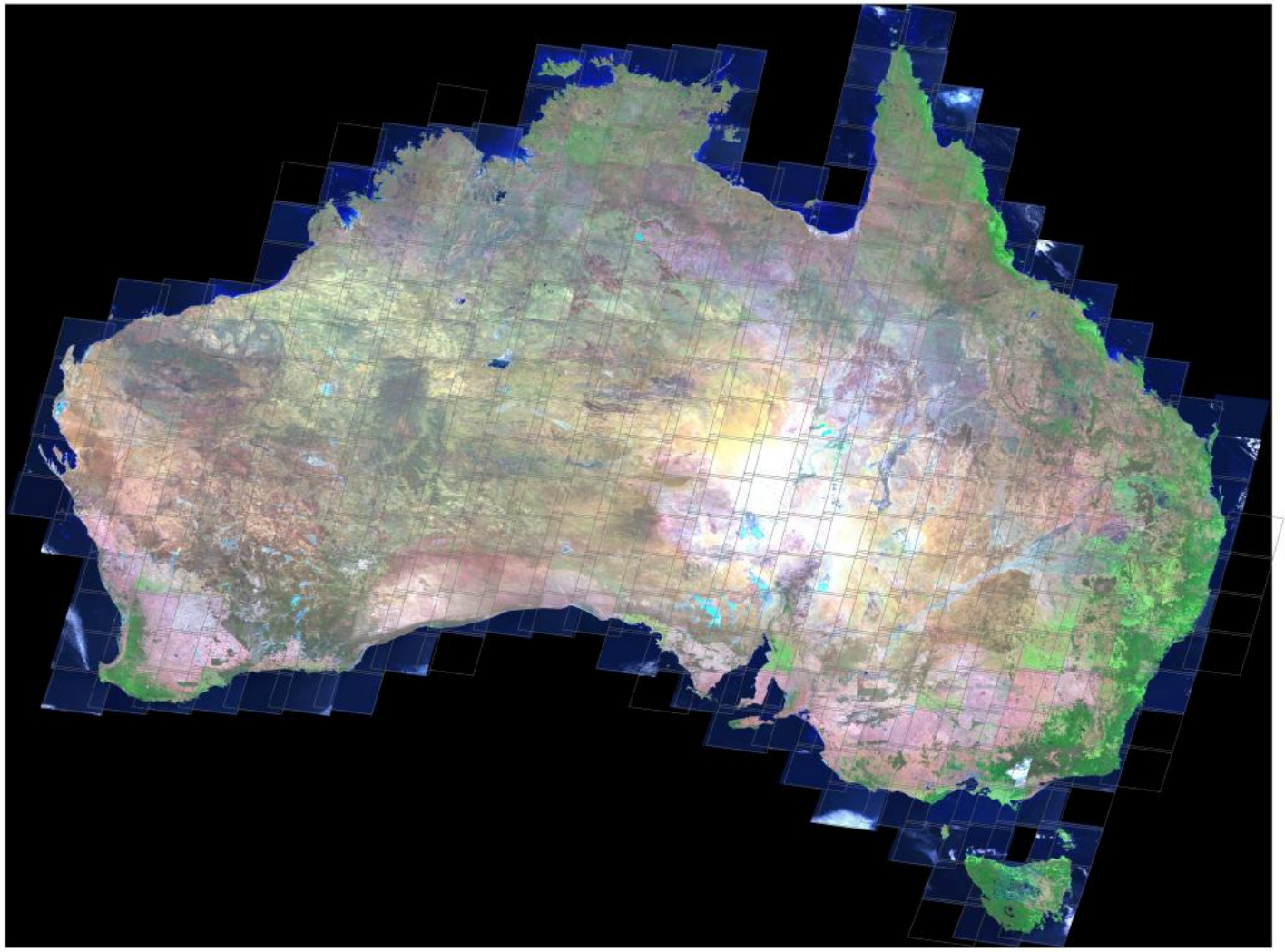
Landsat pre-processing



Landsat at-sensor radiance

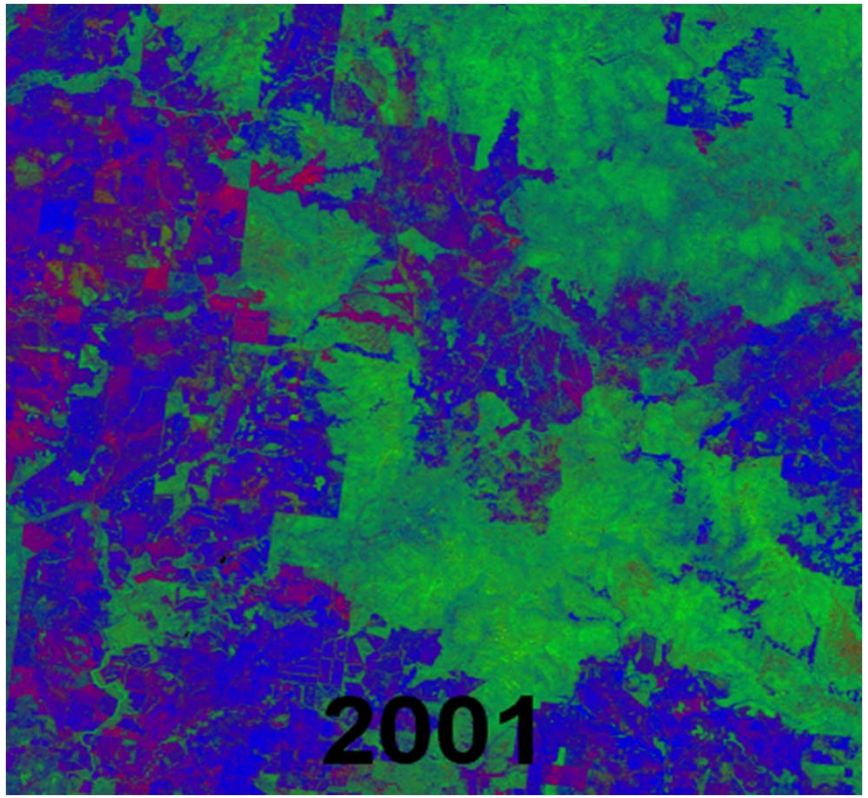
Landsat pre-processing

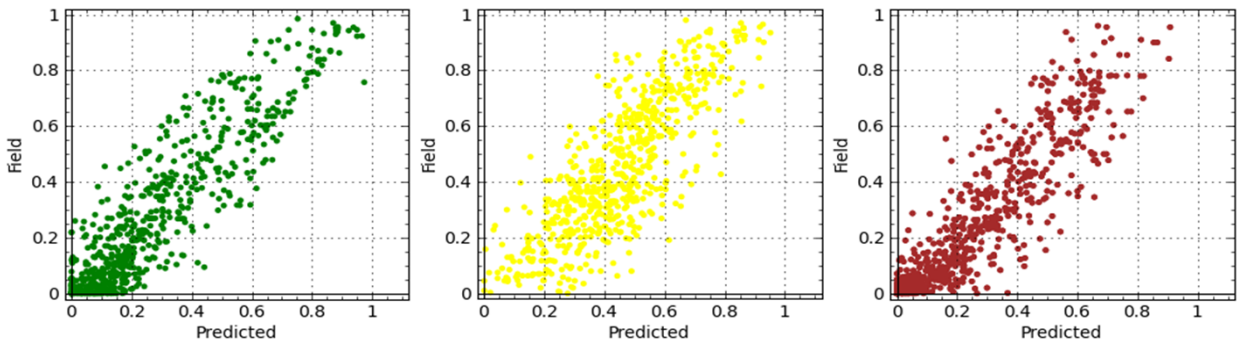


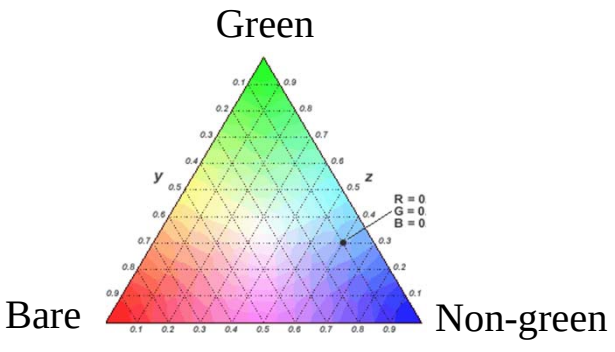
Nadir-adjusted surface reflectance

Fractional cover

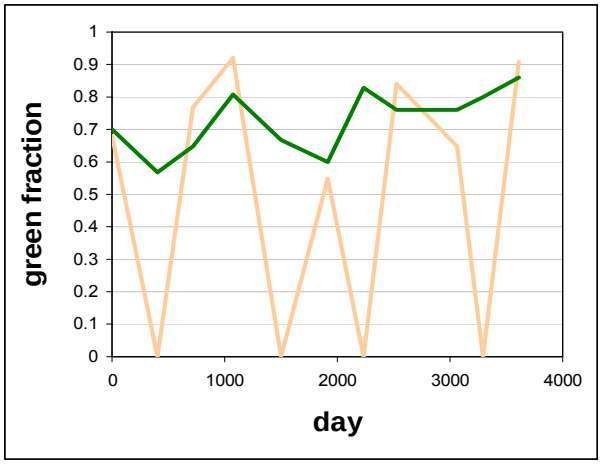
- Fractional cover uses a constrained unmixing model with endmembers derived from field sampling.
- Creates an image with the percentage bare, green and non-green fractions
- Over 800 field sites collected using a consistent, nationally agreed protocol
- Overall RMSE of 11%

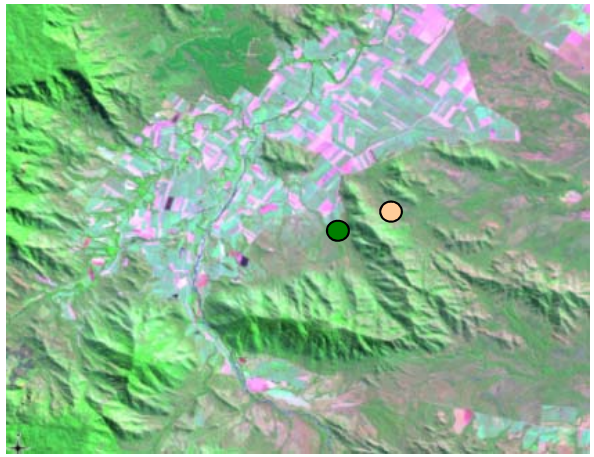




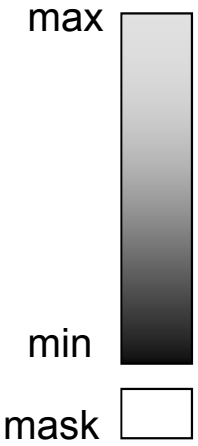


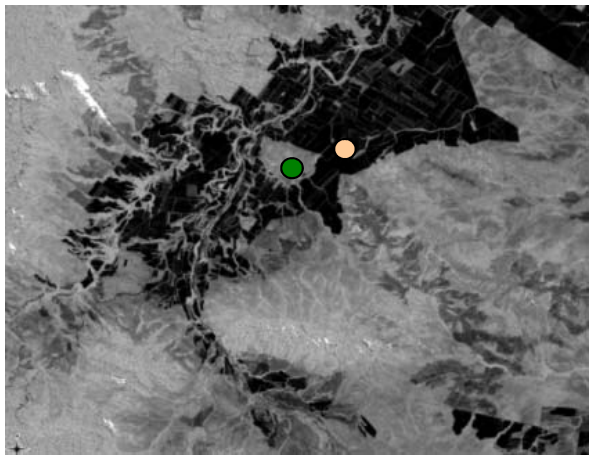
Persistent Green Fraction



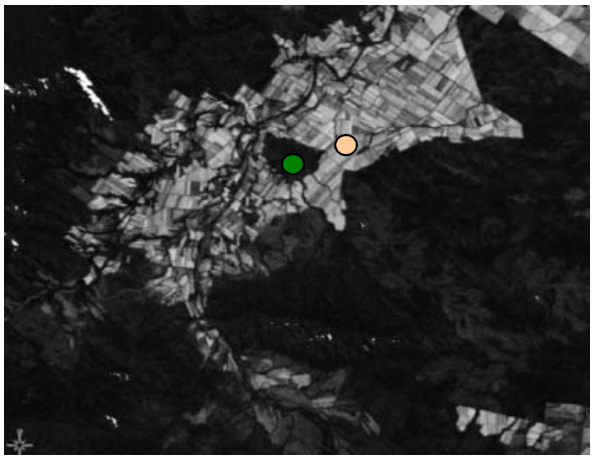


- Robust regression fit to time series of green fraction – robust to account for outliers due to misclassified cloud (or other masked pixel).
- Persistent areas show low variation in green fraction within the time series, and a minimum above a threshold.
- Improved estimation of forest/non-forest

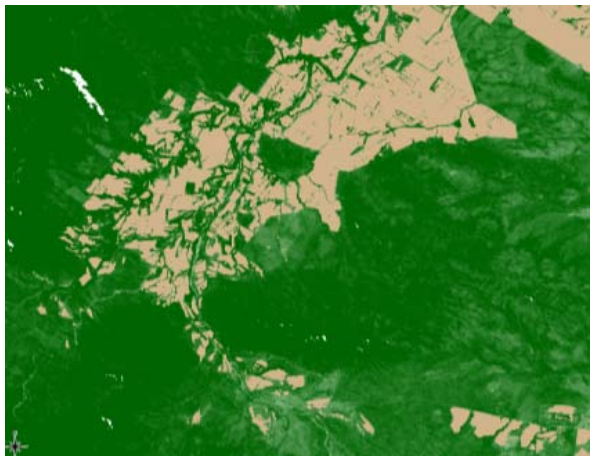




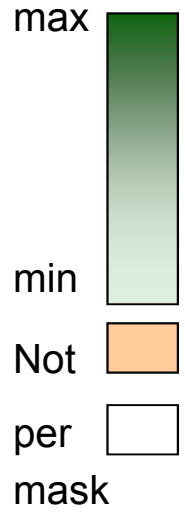
Minimum fraction in time series



Variation in time series



Persistent green fraction



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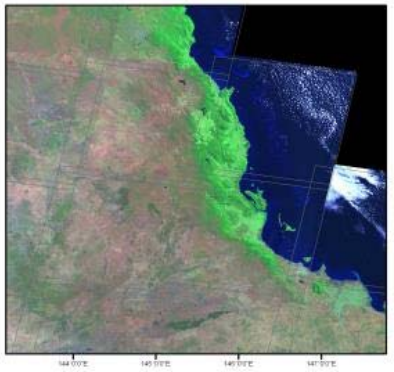
Persistent Green Fraction

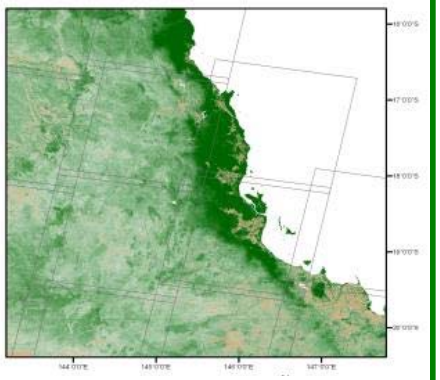
max

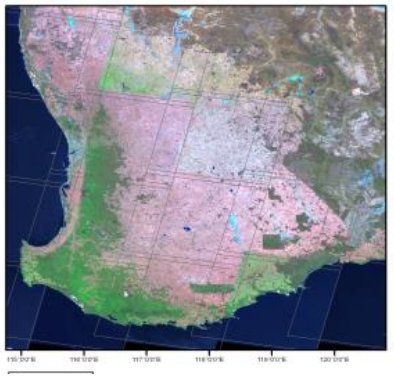
min

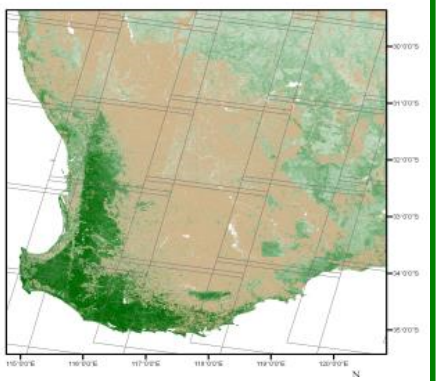
Not per

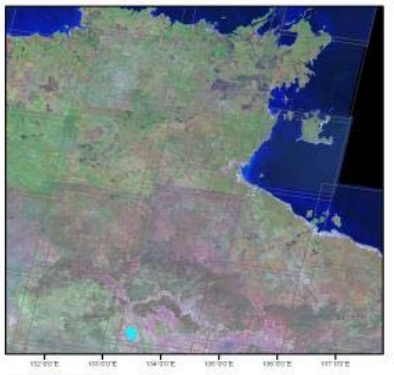
mask

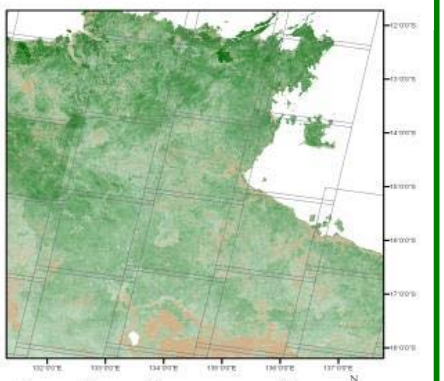












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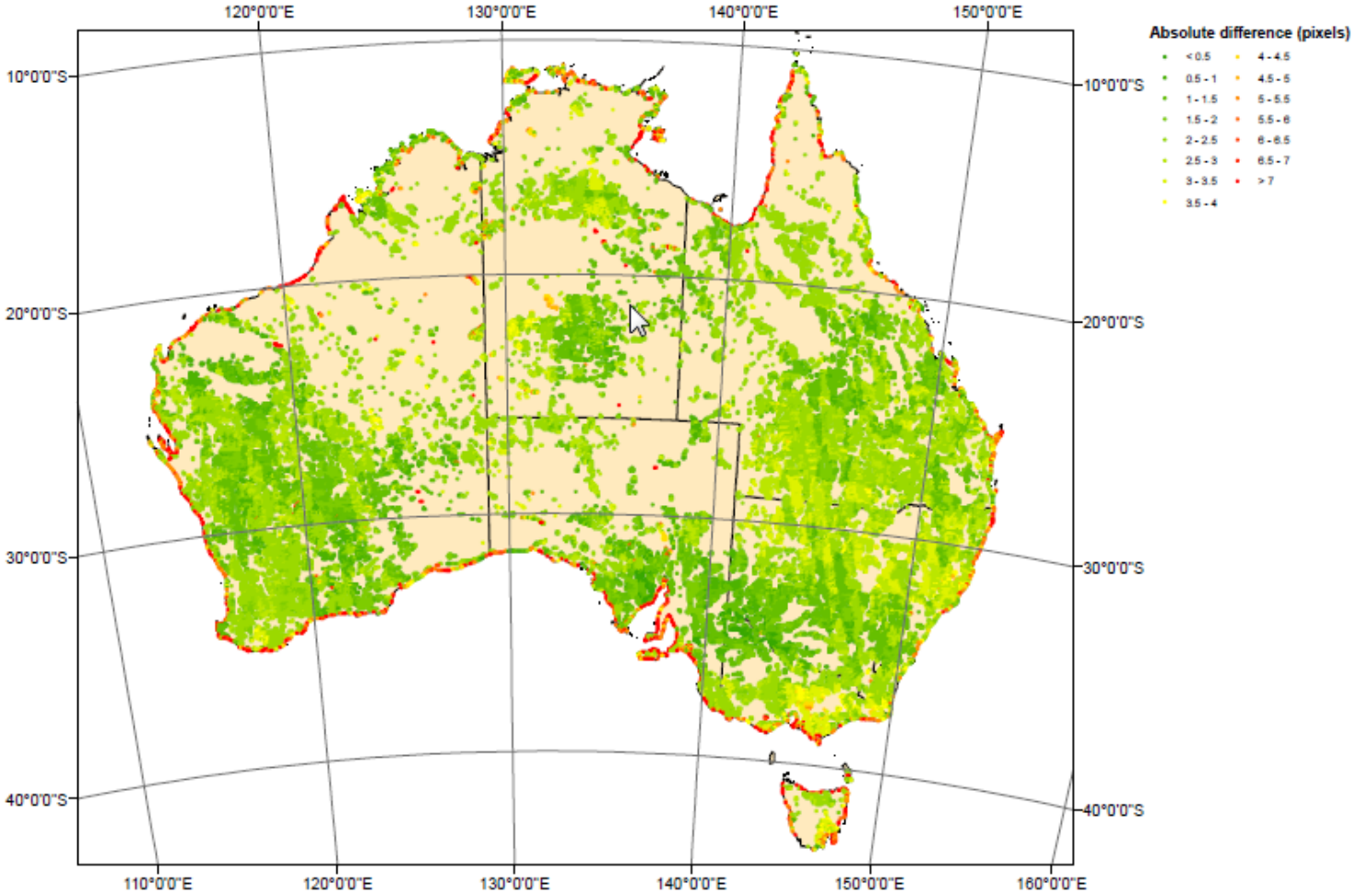
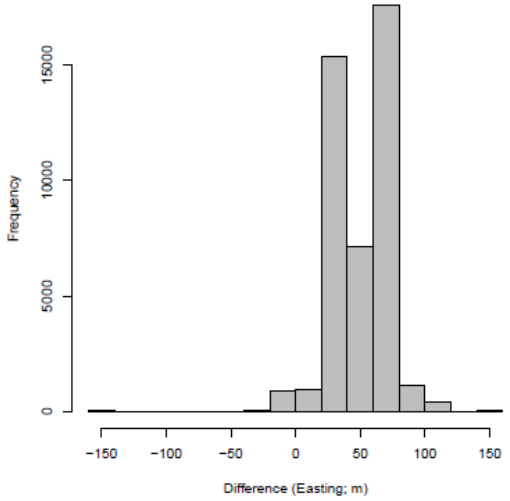
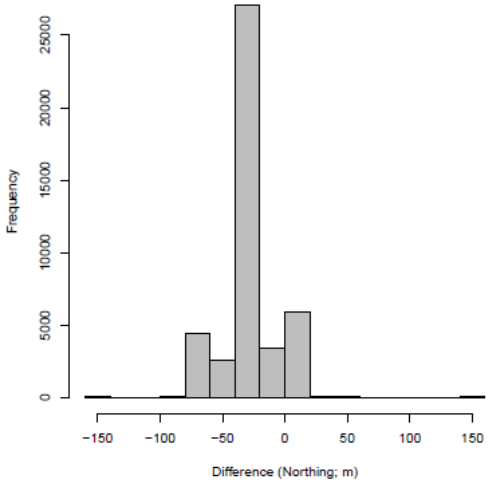
Registration of Landsat and ALOS PALSAR

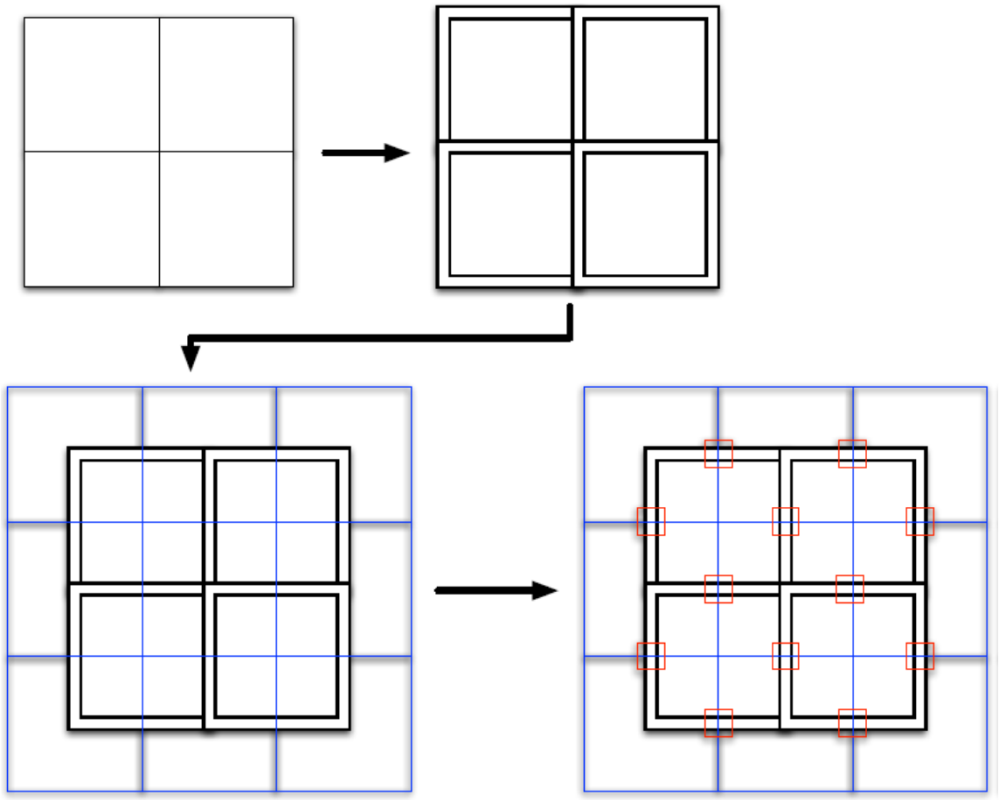


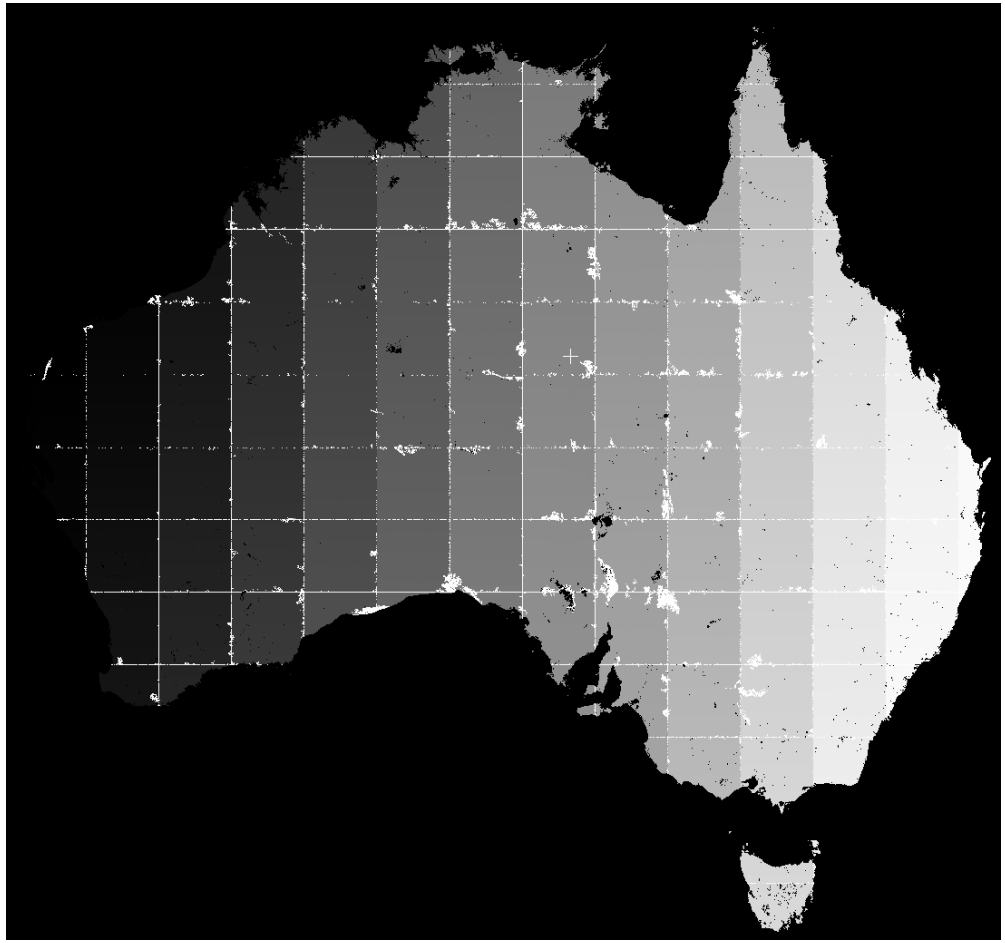




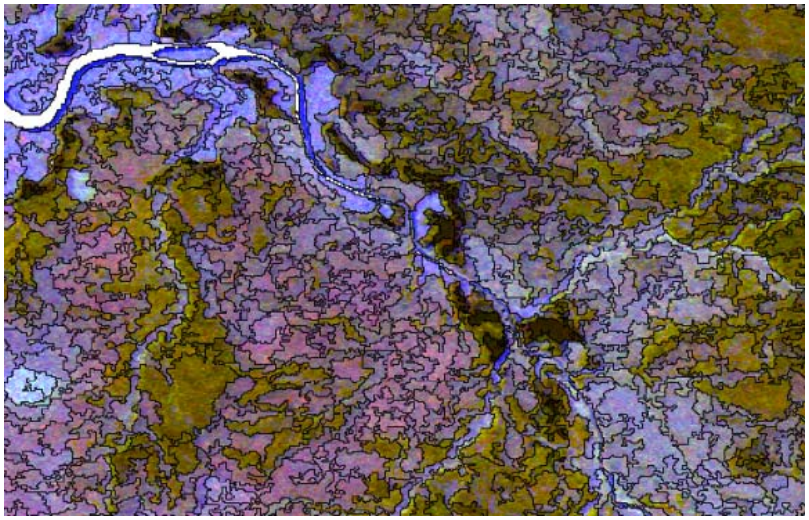
Large area segmentation

- Open source development through *RSGISLib*
  - 33,778,634 clumps using *k* = 30 and *n* = 100 pixels

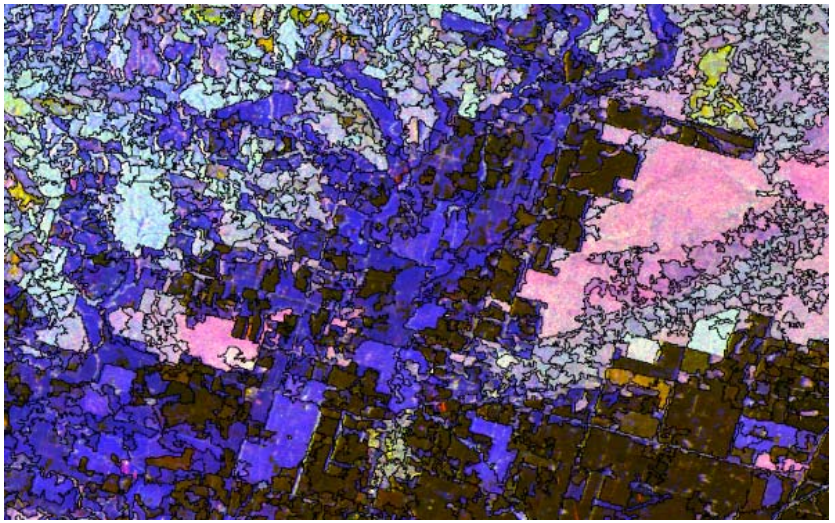




North Queensland



Southern Victoria



L-HH

L-HV

PGF

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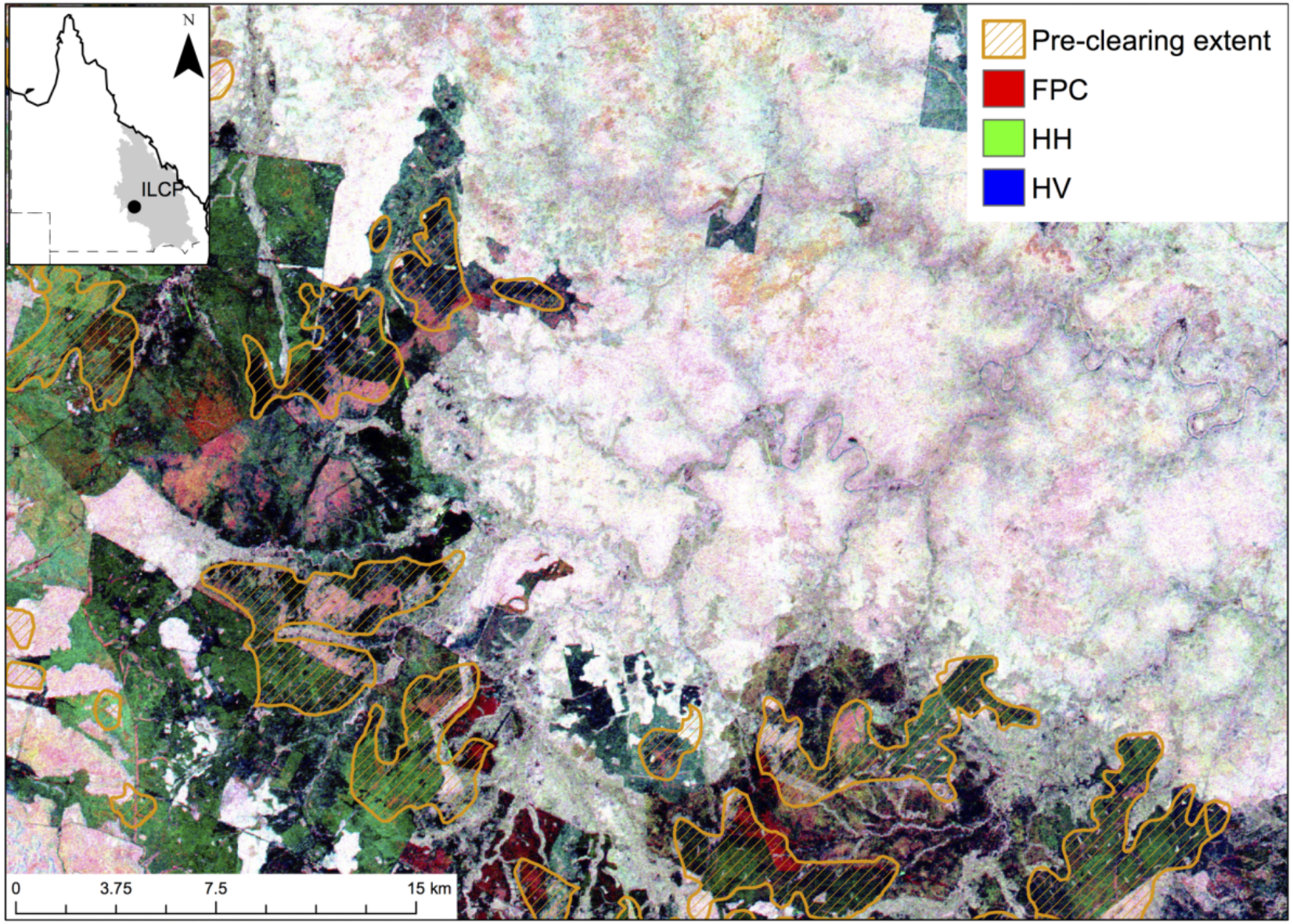
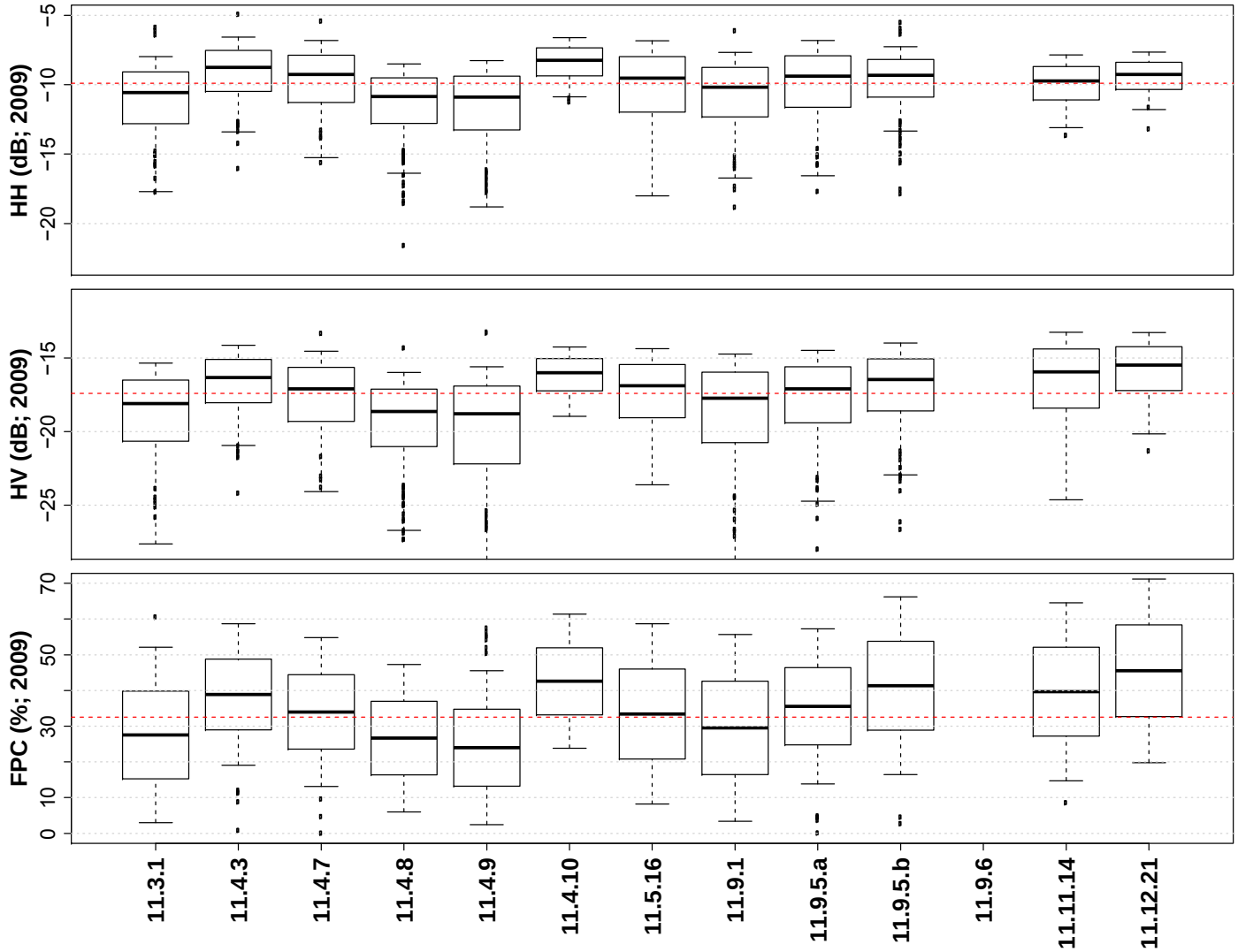
Forest Growth Stage Mapping, Brigalow Belt Bioregion



Characteristics of Remnant Vegetation, Brigalow Belt Bioregion



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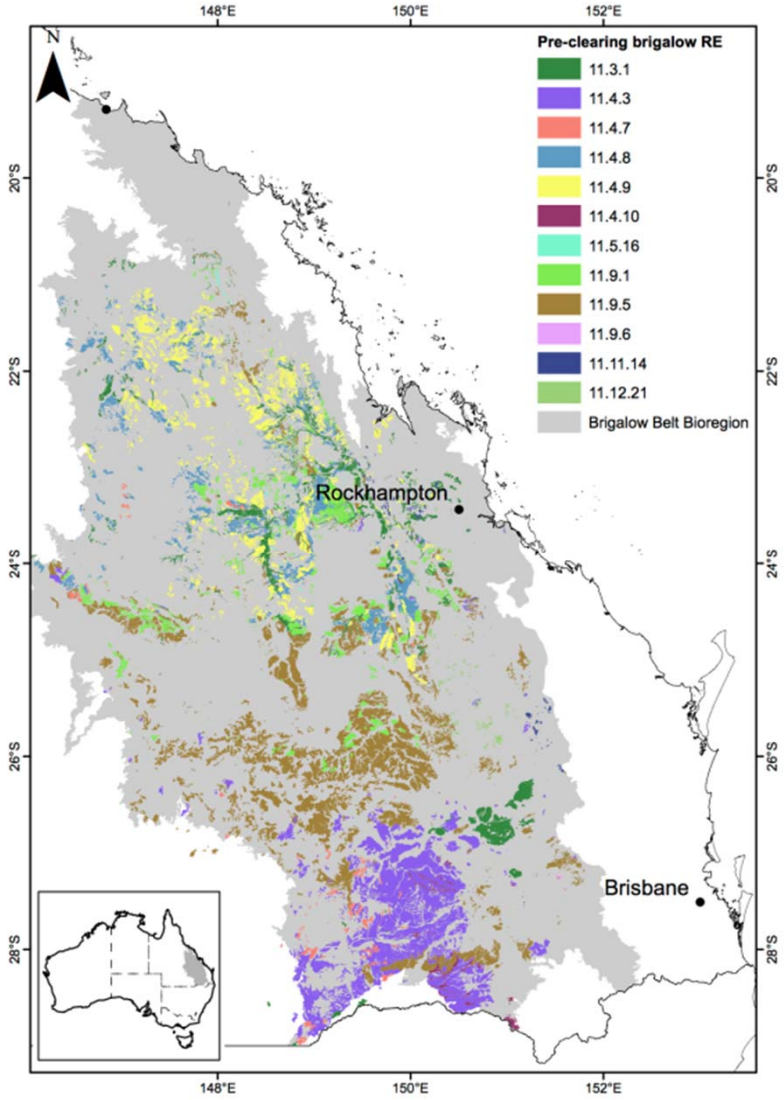
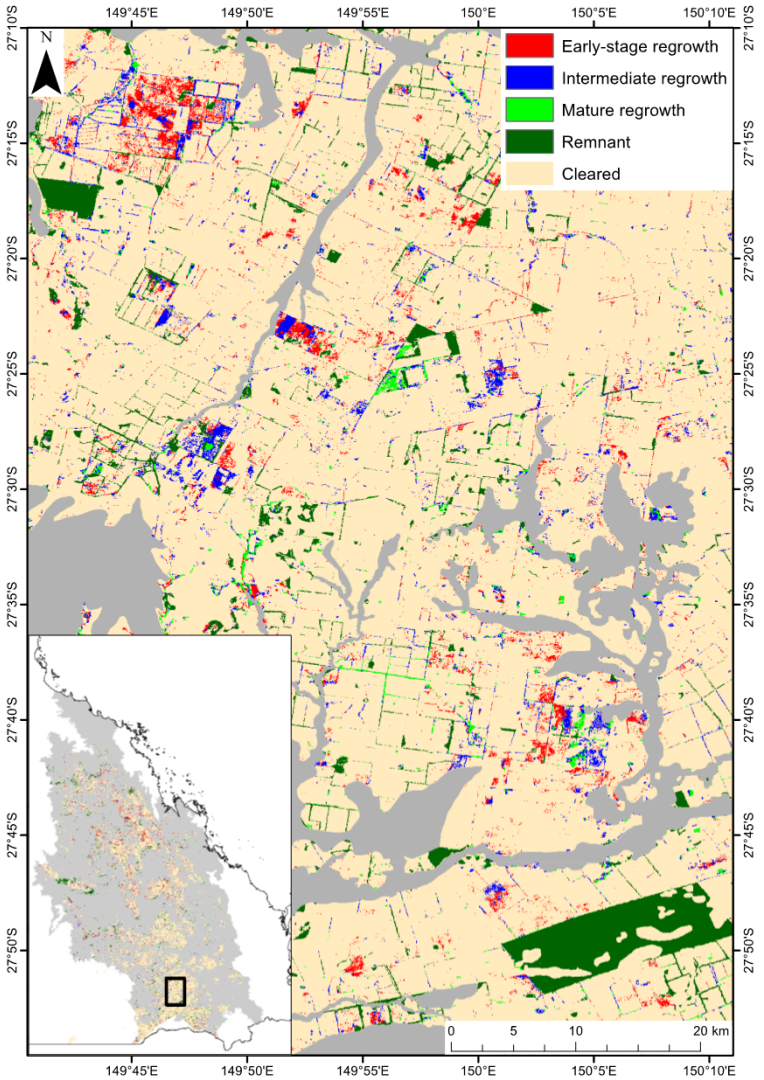


12 RE's with Brigalow



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

Presentation Outline

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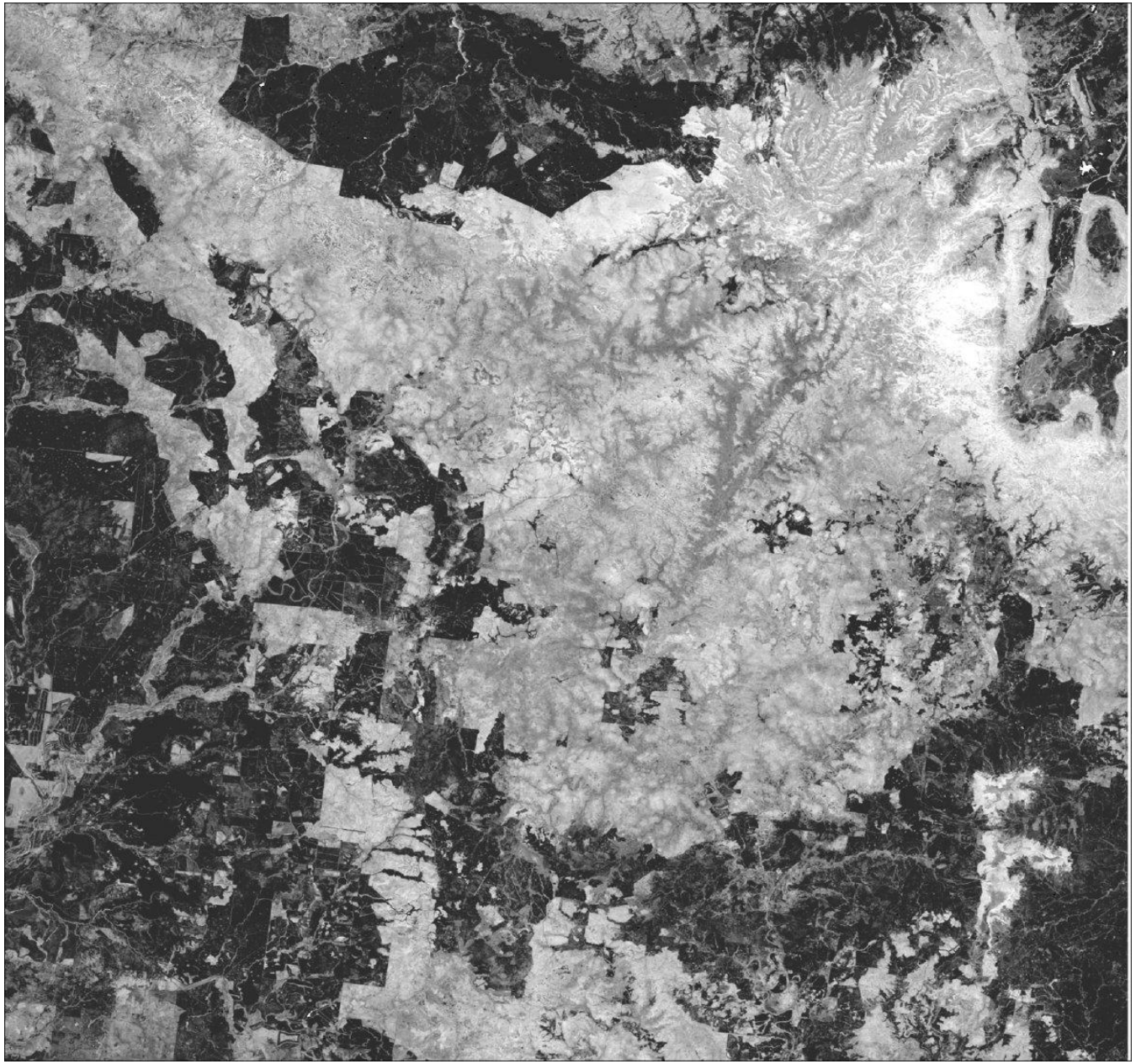
- Australian above-ground biomass product development
- Case studies of mapping and modelling biomass change



Enhanced Retrieval of AGB

Landsat Foliage Projective Cover

L-band HH

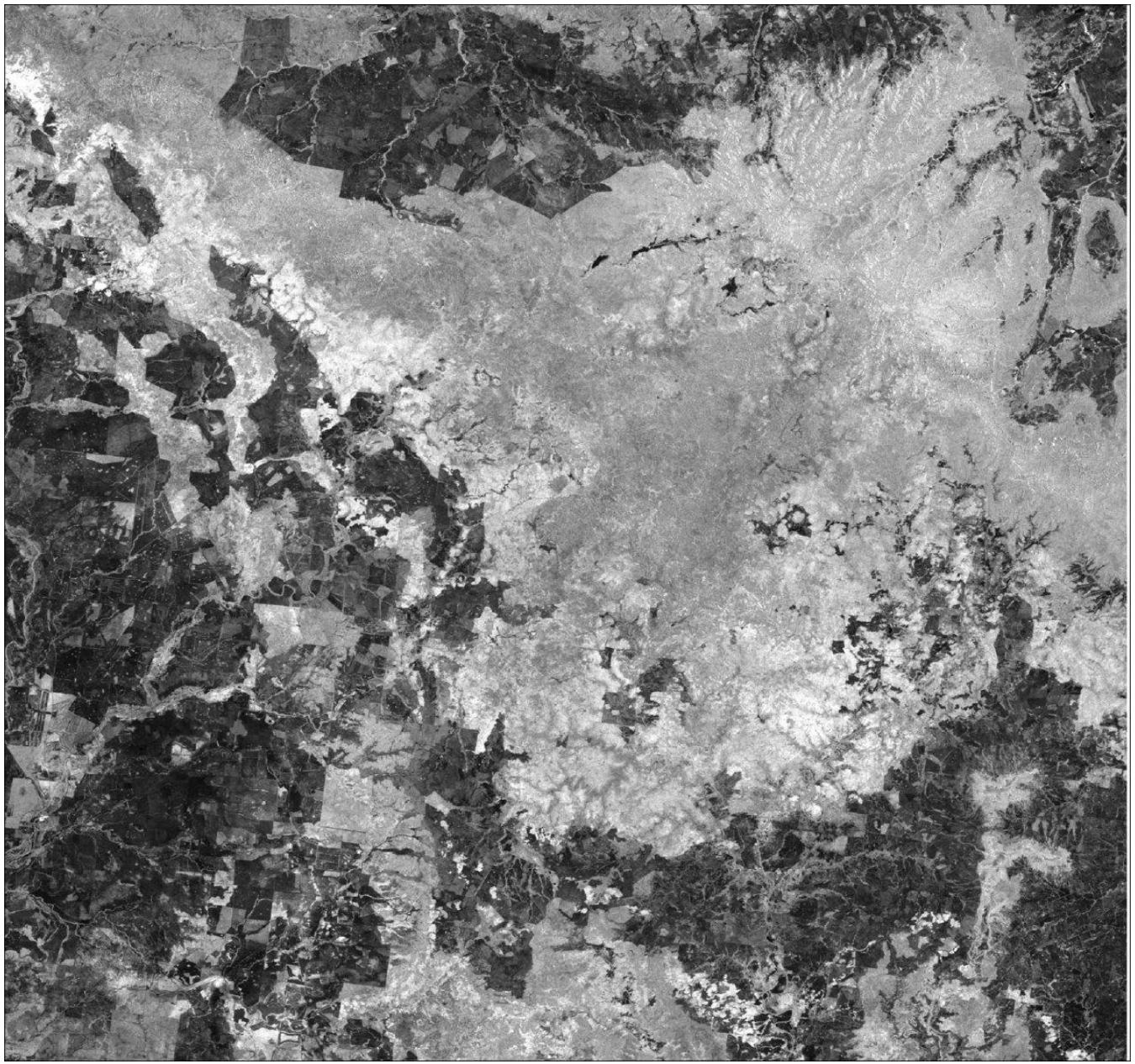
L-band HV

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

ICESAT GLAS

Segmentation

Stand Height Retrieval



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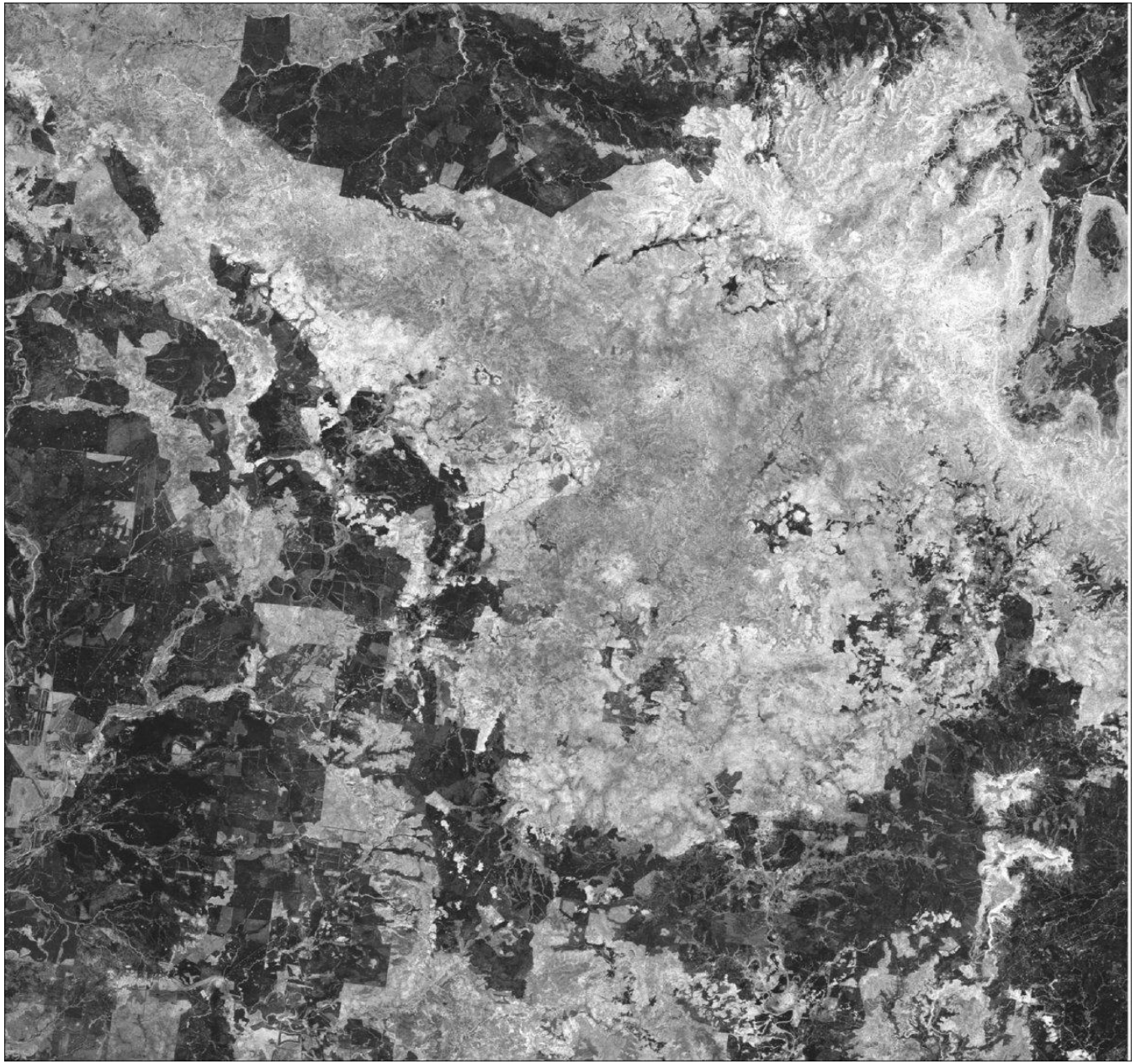

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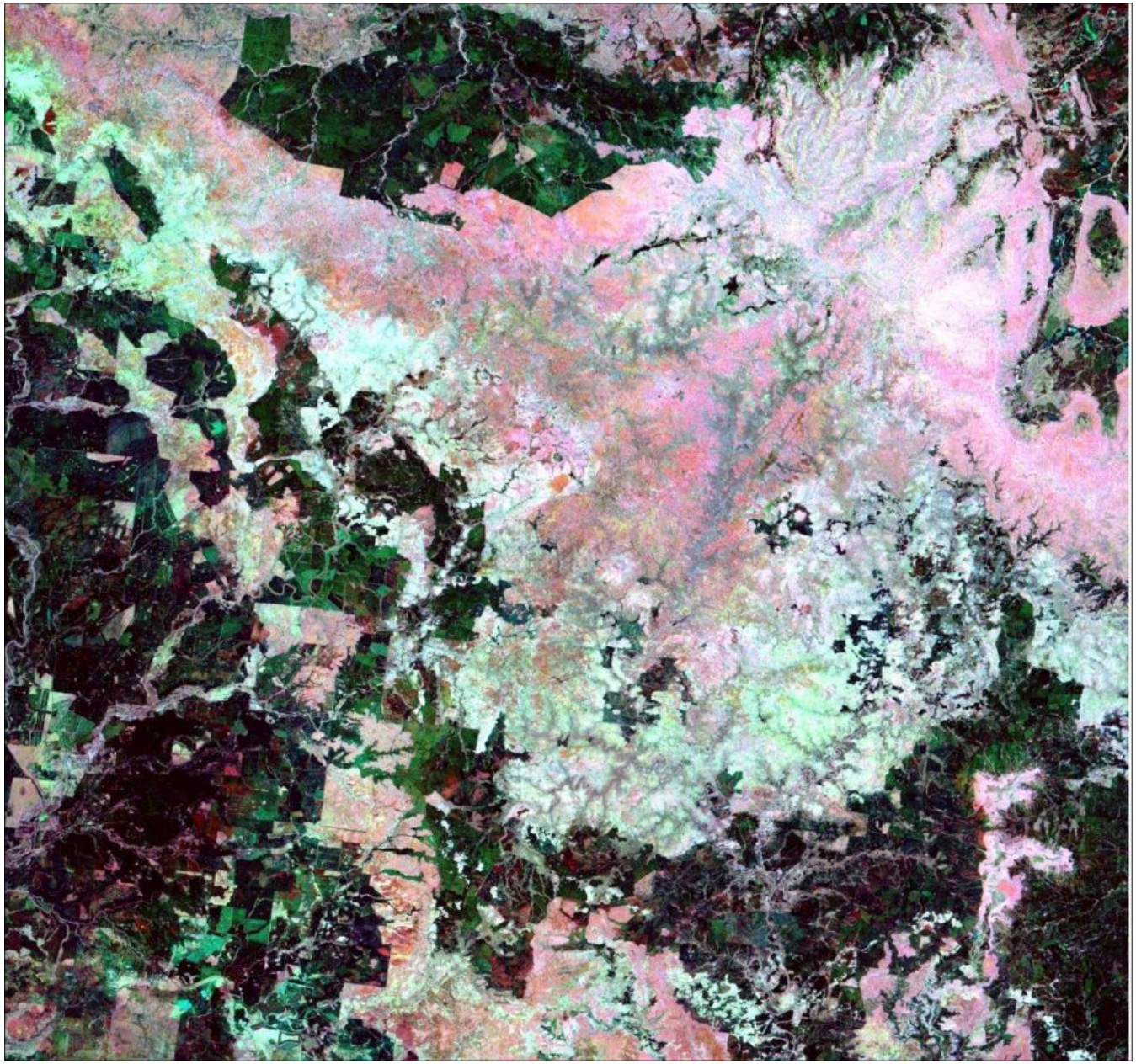

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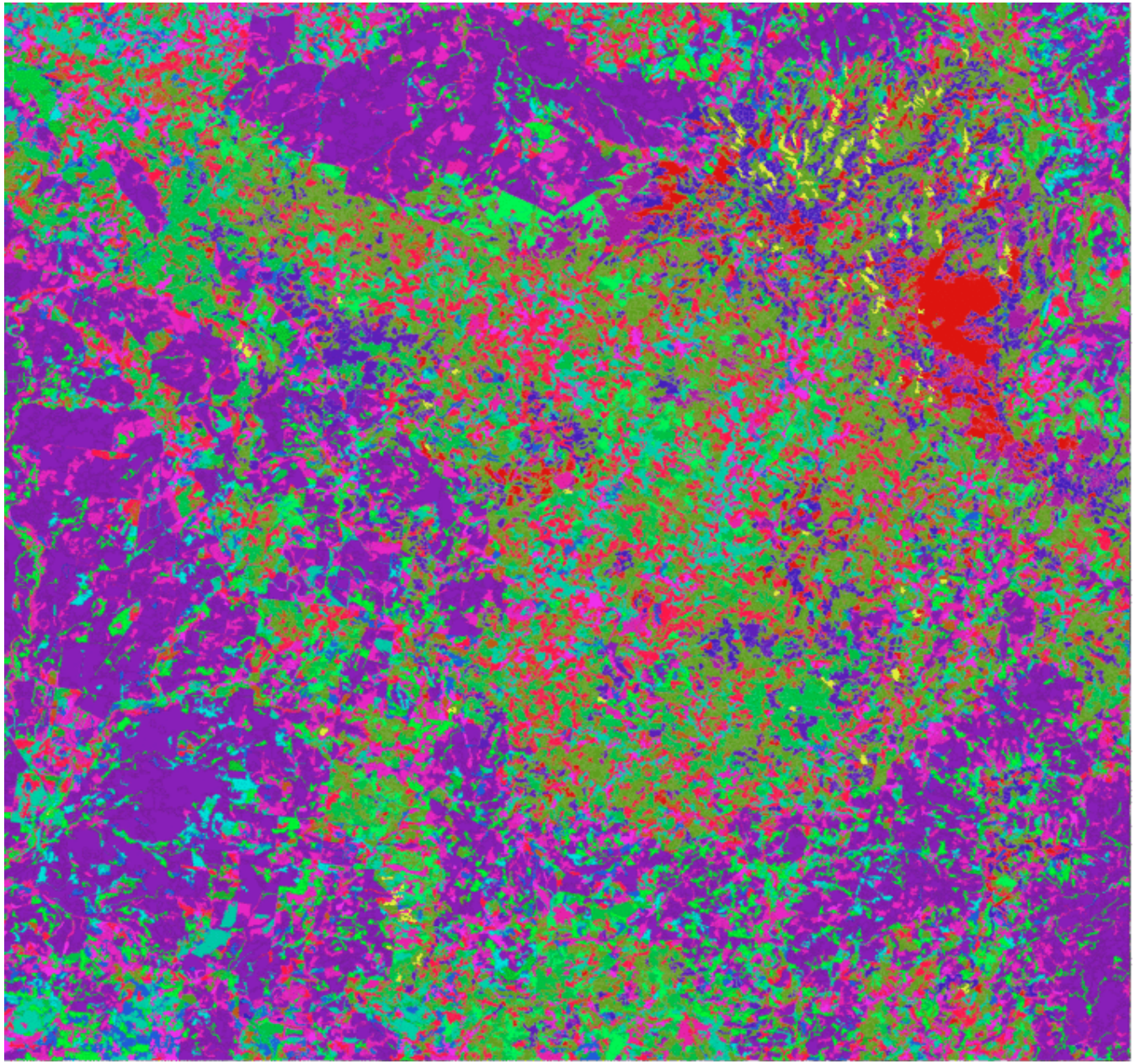

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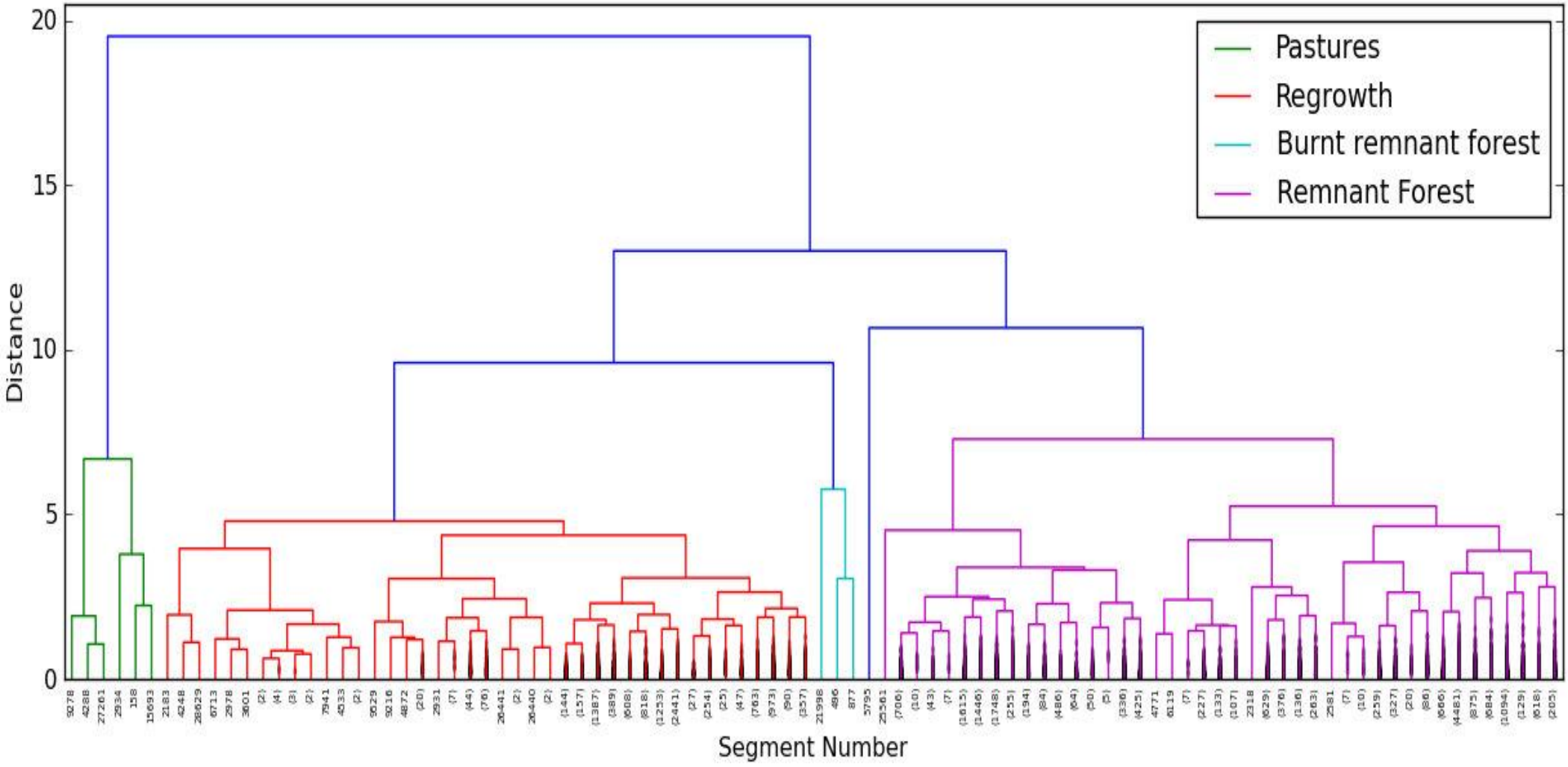
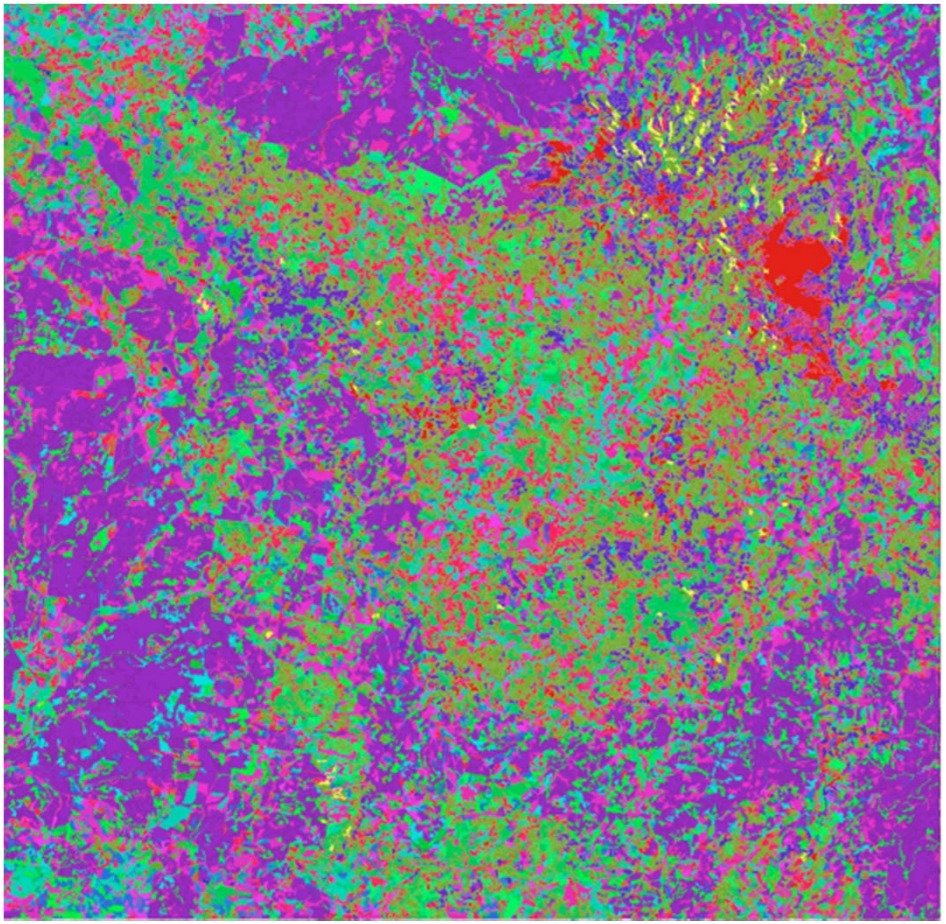
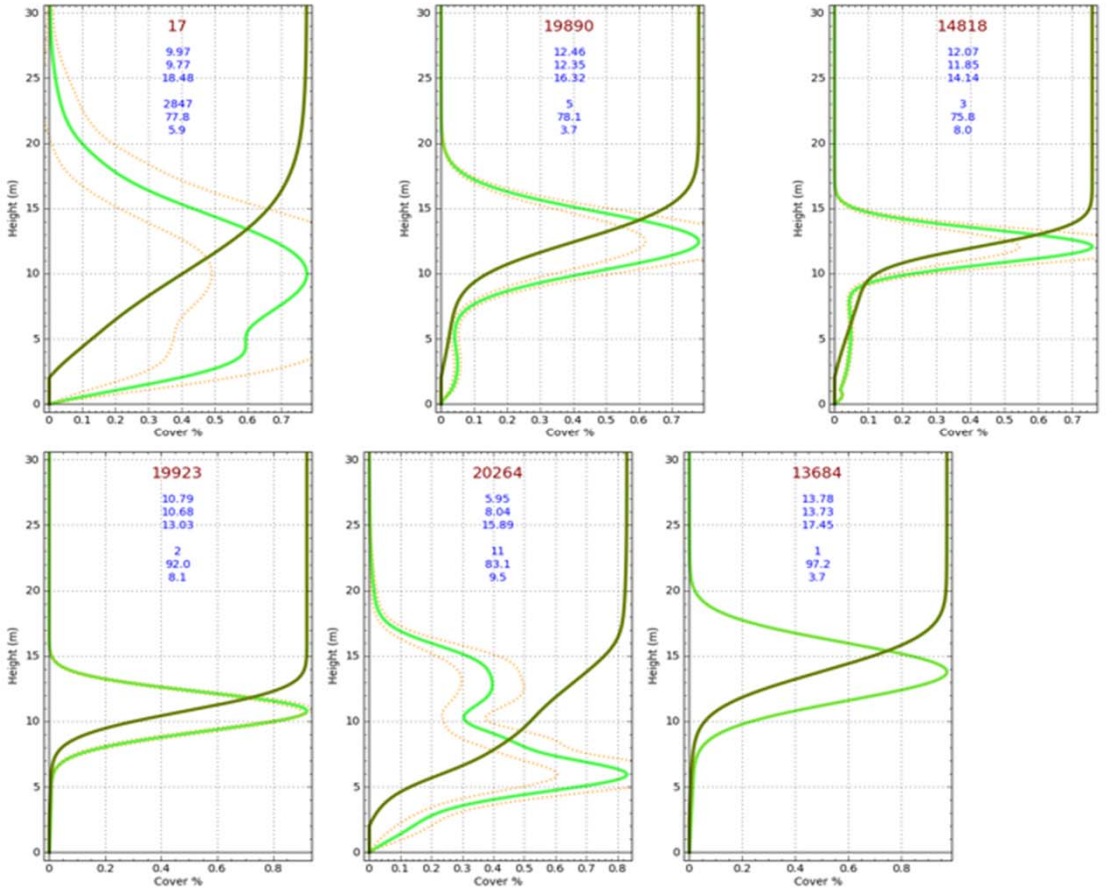
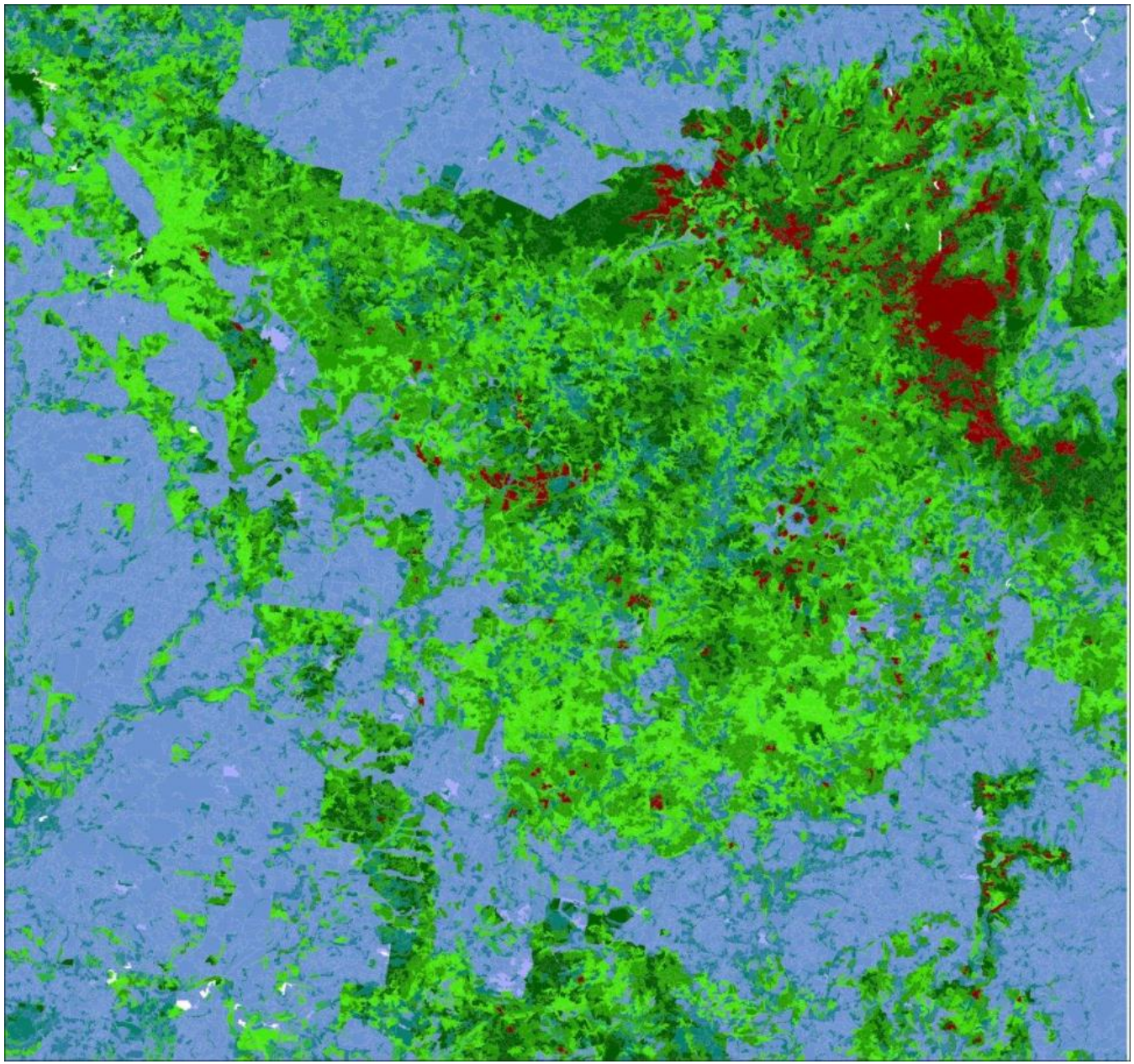
Clustering of Segments (Using SciPy)







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



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L-band HH

L-band HV

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

ICESAT GLAS

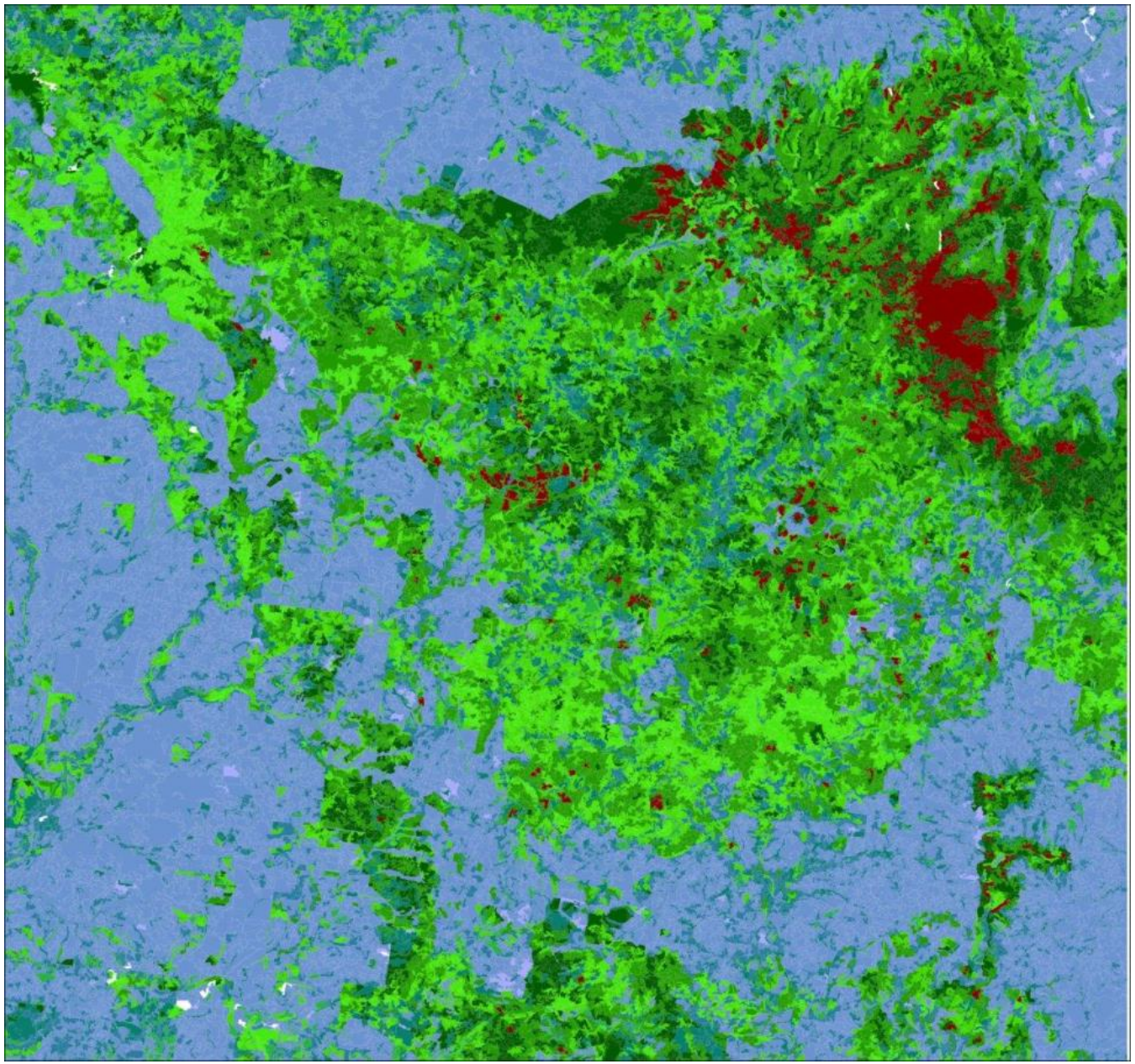
Segmentation

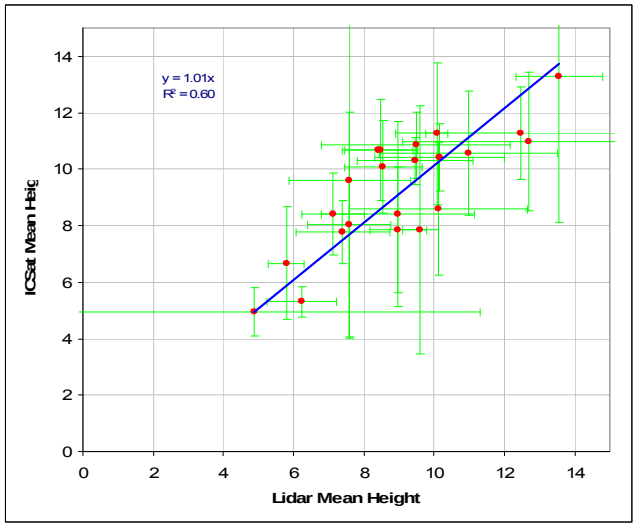
Stand height retrieval

ALOS

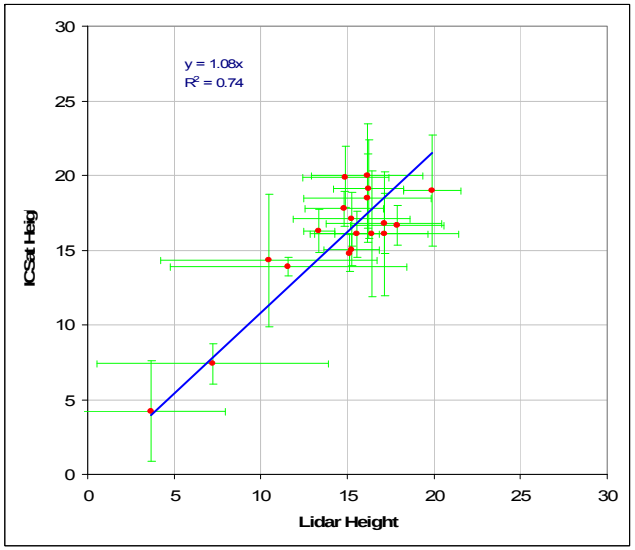
K&C Initiative

An international science collaboration led by JAXA





Comparison with ICESAT



Comparison with airborne lidar

ALOS

K&C Initiative

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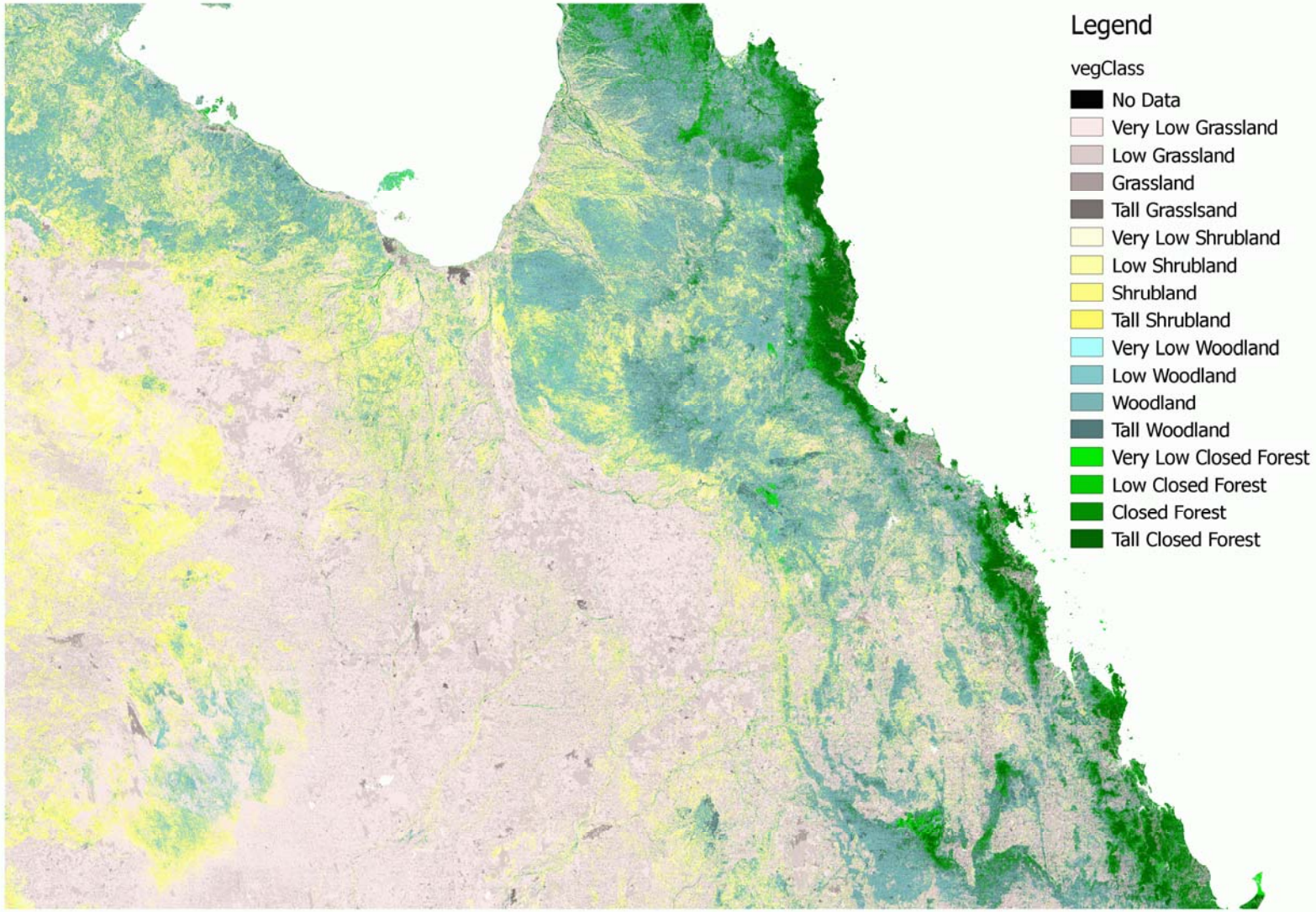
Preliminary structural formation classification over Eastern Australia



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ALOS

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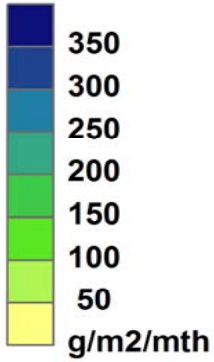
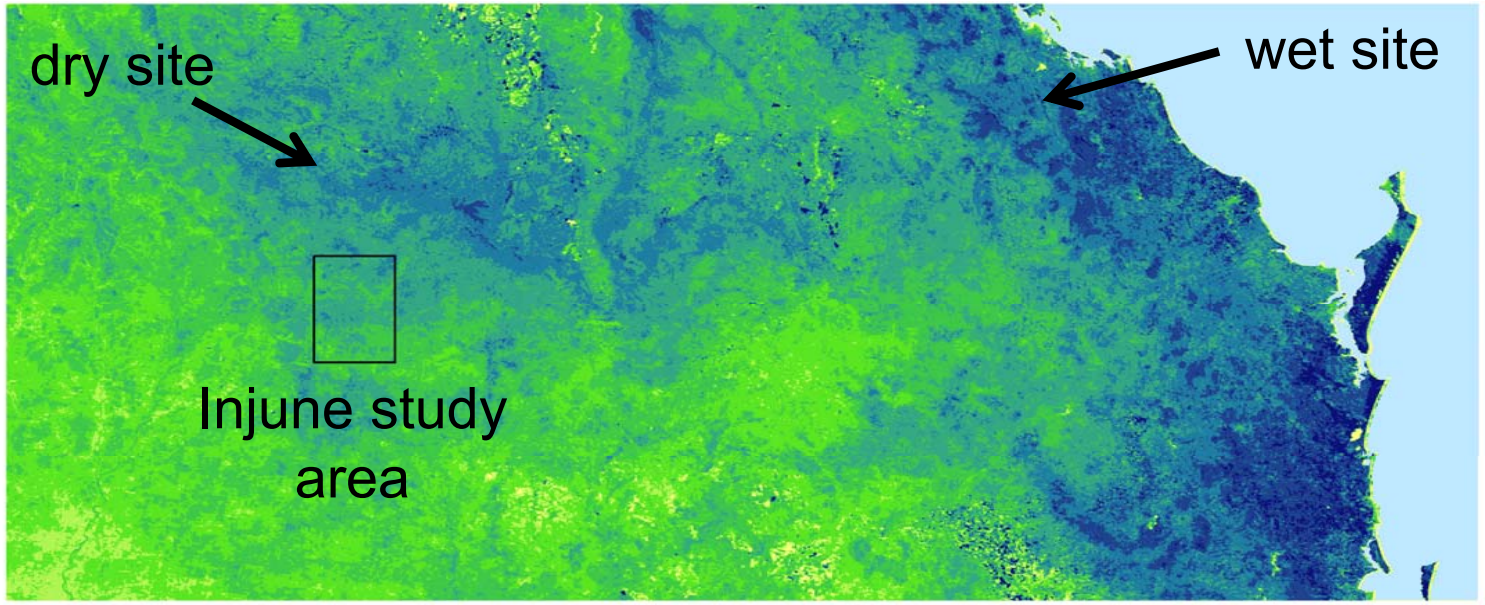
GPP and C mass

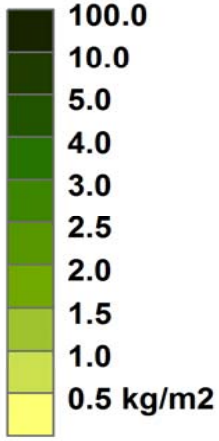
Total GPP

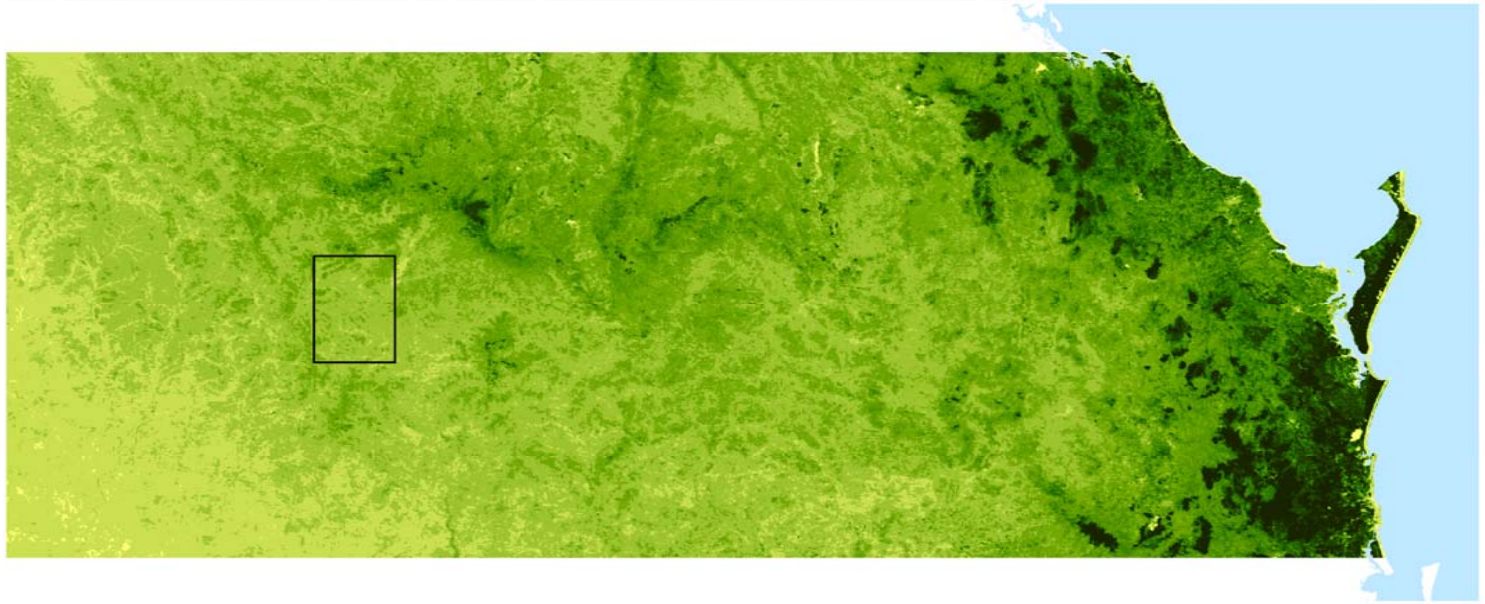




$1\ kg\ m^{-2} = 10\ t\ ha^{-1}$

Total carbon mass

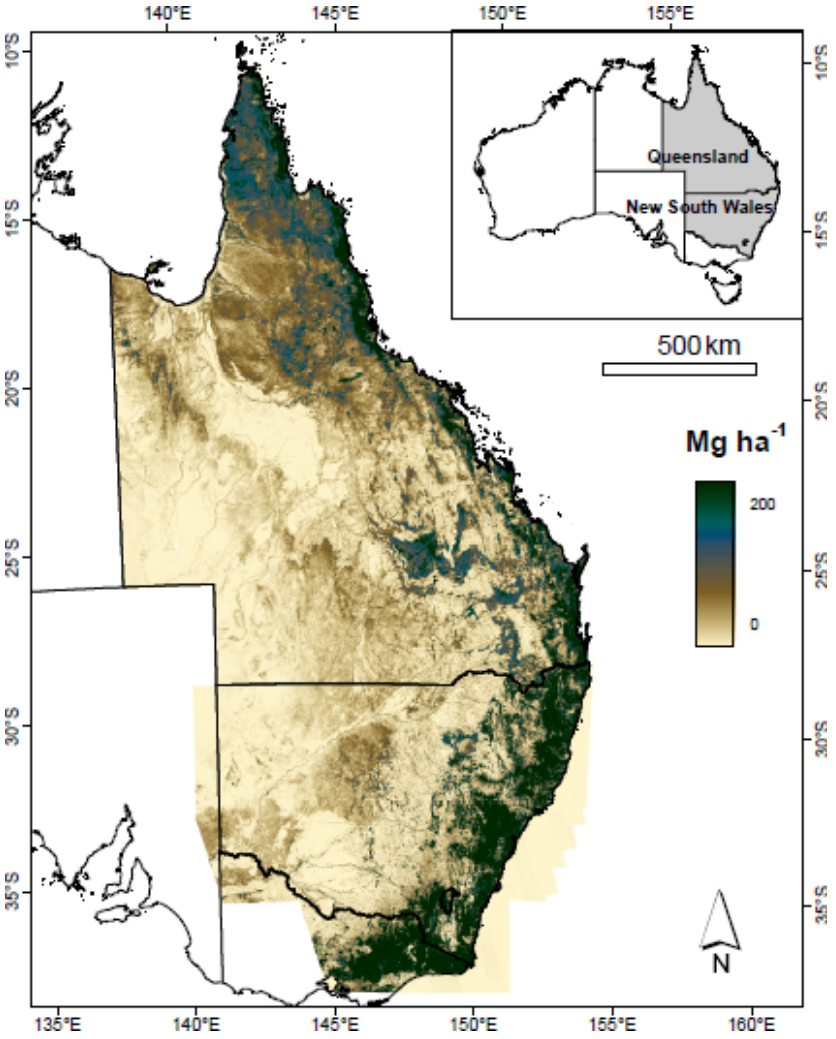


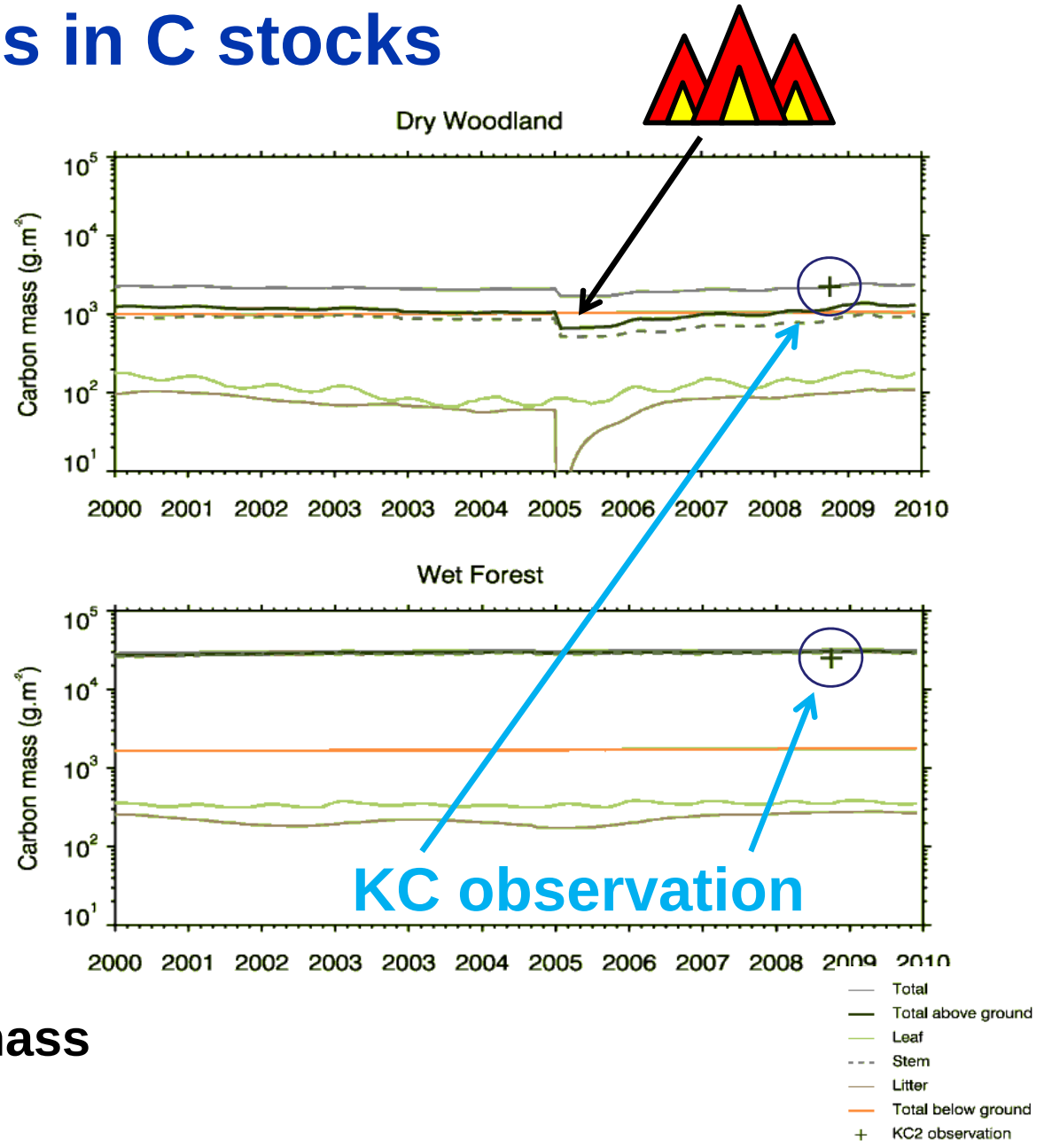


CSIRO

ABDAS | Randall Donohue, Luigi Renzullo, Alex Held

Dynamics in C stocks





N.B. Carbon mass ≈ 0.5 x biomass

1 kg m^{-2} = 10 t ha^{-1}

Acknowledgements:

- JAXA
- Queensland DSITIA
  - Remote Sensing Centre
  - Queensland Herbarium
- University of Queensland (JRSRP)
- University of New South Wales
- NSW OEH
- University of Massachussetts
- Tropical Research Institute, Portugal
- CSIRO Land & Water