

Post-K&C – First Report

Fusion of ALOS-2 and Spaceborne Lidar Observations for High Resolution Mapping of Degraded and Regenerating Forest Structure and Biomass in Australia

John Armston^{1,2}

Peter Scarth², Anthea Mitchell^{3,2}

Oliver Cartus⁴, Richard Lucas⁵

¹ University of Maryland

² JRSRP, University of Queensland

³ University of New South Wales

⁴ Gamma Remote Sensing

⁵ University of Aberystwyth

Presentation outline

1. Project aim and drivers
2. JRSRP data products
3. Post-K&C research objectives
4. Study sites and characteristics
5. Methods, results and significant findings
6. Deliverables and other outputs
7. PALSAR/PALSAR-2 data access
8. Acknowledgements

Project aim and drivers

- The aim of this research is enhanced mapping of degraded and regenerating forest structure and aboveground biomass in Australia through fusion of ALOS-2 PALSAR-2 image data with contemporaneous spaceborne lidar observations



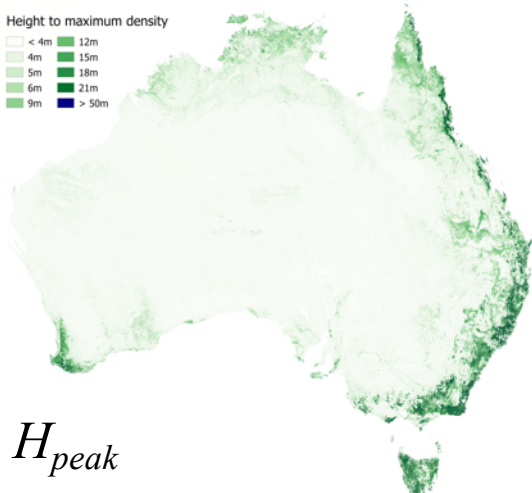
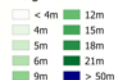
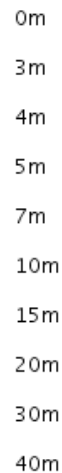
- JAXA ALOS-2 PALSAR-2 represent the only repeat global L-band SAR observations that are coincident with these new spaceborne lidar missions

Project aim and drivers

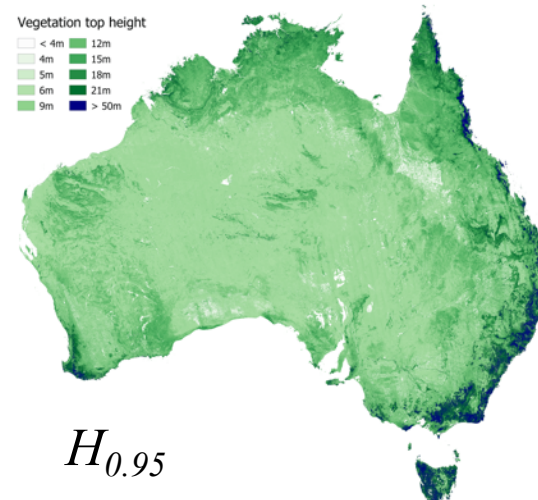
- **Project aims support coordination of biomass product calibration and validation activities in Australia**
 - ⇒ CEOS Land Product Validation Biomass Focus Area
 - ⇒ Focus on SuperSites in use by the NASA GEDI, NASA/ISRO NISAR, ESA BIOMASS, and JAXA missions
 - ⇒ Collaboration with ESA CCI+ Biomass Initiative (Cartus, Lucas)
- **Project aims support *K&C thematic drivers***
 - ⇒ Carbon cycle science – products are relevant to carbon data assimilation schemes, carbon offsets research and national reporting frameworks
 - ⇒ Environmental Conservation – regional mapping at a scale relevant to land management, State Government vegetation management policy, and State of the Forests reporting

Australian Vertical Plant Profile Metrics (Phase 3 & 4)

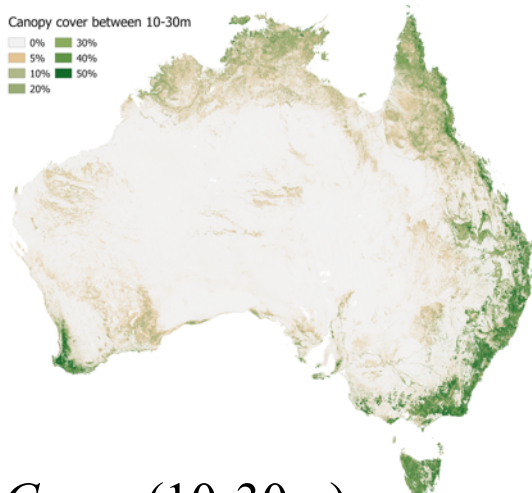
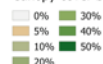
Height to maximum density

 H_{peak} 

Vegetation top height

 $H_{0.95}$

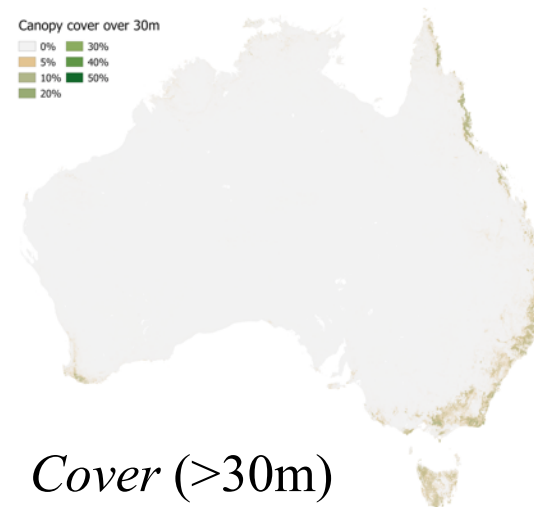
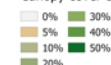
Canopy cover between 10-30m



Cover (10-30m)

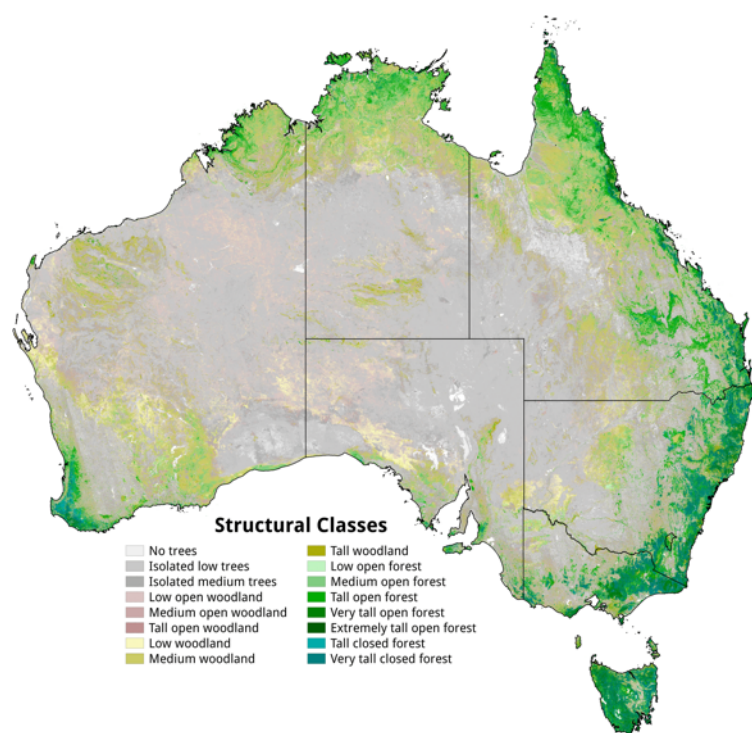
Scarth, Armston, Lucas & Bunting (2019). *A Structural Classification of Australian Vegetation Using ICESat/GLAS, ALOS PALSAR, and Landsat Sensor Data*. *Remote Sens.* 2019, 11, 147.

Canopy cover over 30m



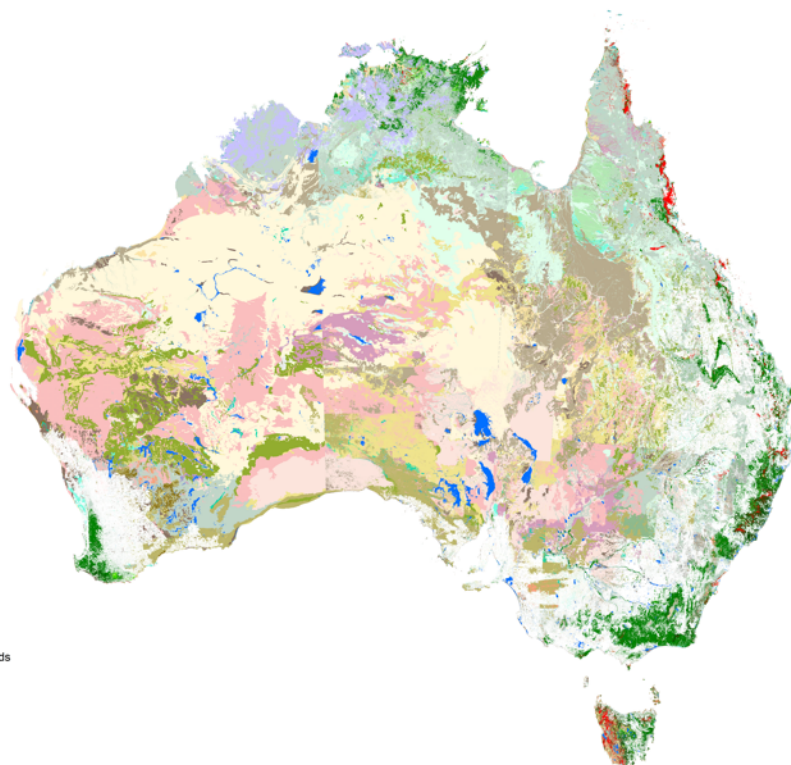
Cover (>30m)

Australian Vegetation Structural Formations (Phase 3 & 4)



Major Vegetation Groups

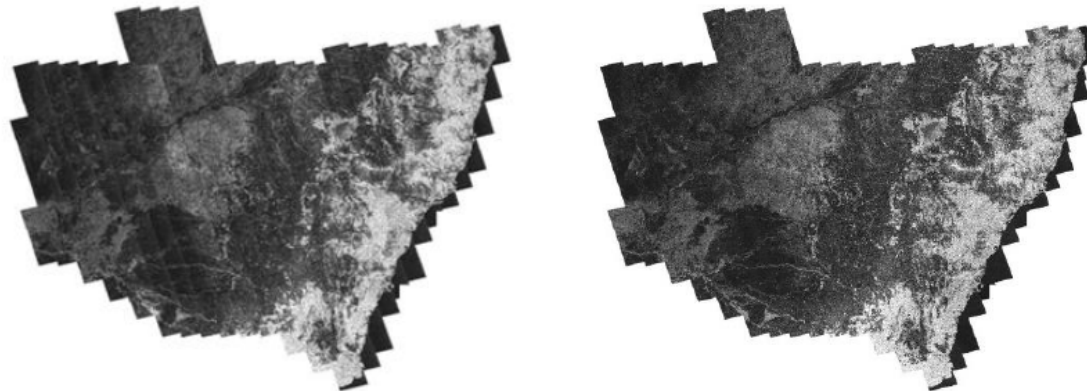
- Unknown/no data
- Unclassified native vegetation
- Unclassified Forest
- Tussock Grasslands
- Tropical Eucalypt Woodlands/Grasslands
- Sea and estuaries
- Regrowth, modified native vegetation
- Rainforests and Vine Thickets
- Other Shrublands
- Other Open Woodlands
- Other Grasslands, Herblands, Sedgeland and Rushlands
- Other Forests and Woodlands
- Naturally bare - sand, rock, claypan, mudflat
- Melaleuca Forests and Woodlands
- Mangroves
- Mallee Woodlands and Shrublands
- Mallee Open Woodlands and Sparse Mallee Shrublands
- Low Closed Forests and Tall Closed Shrublands
- Inland aquatic - freshwater, salt lakes, lagoons
- Hummock Grasslands
- Heathlands
- Eucalypt Woodlands
- Eucalypt Tall Open Forests
- Eucalypt Open Woodlands
- Eucalypt Open Forests
- Eucalypt Low Open Forests
- Cleared, non-native vegetation, buildings
- Chenopod Shrublands, Samphire Shrublands and Forblands
- Casuarina Forests and Woodlands
- Callitris Forests and Woodlands
- Acacia Shrublands
- Acacia Open Woodlands
- Acacia Forests and Woodlands



Significantly improved detail, consistency and accuracy compared with existing mapping

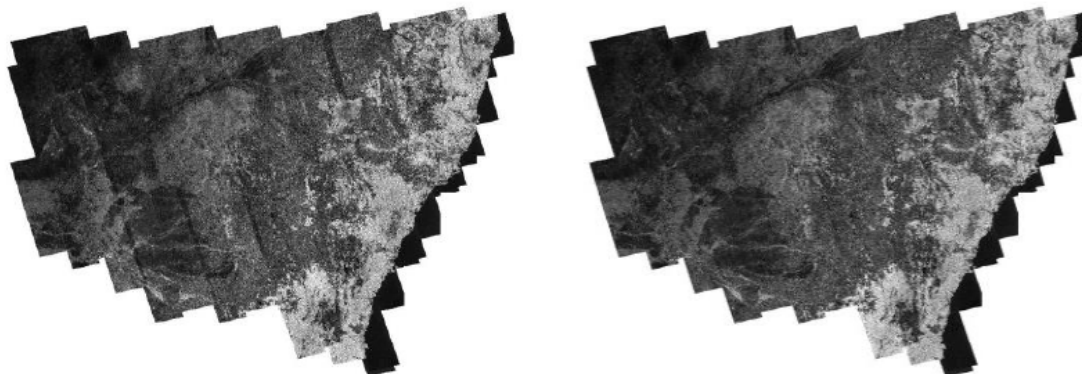
<http://dx.doi.org/10.4227/05/5703458340442>

ALOS-1 Product Images



ALOS-1 (root HV Gamma0) before (left) and after (right) internal matching

ALOS-2 Product Images



ALOS-2 (root HV Gamma0) before (left) and after (right) internal matching

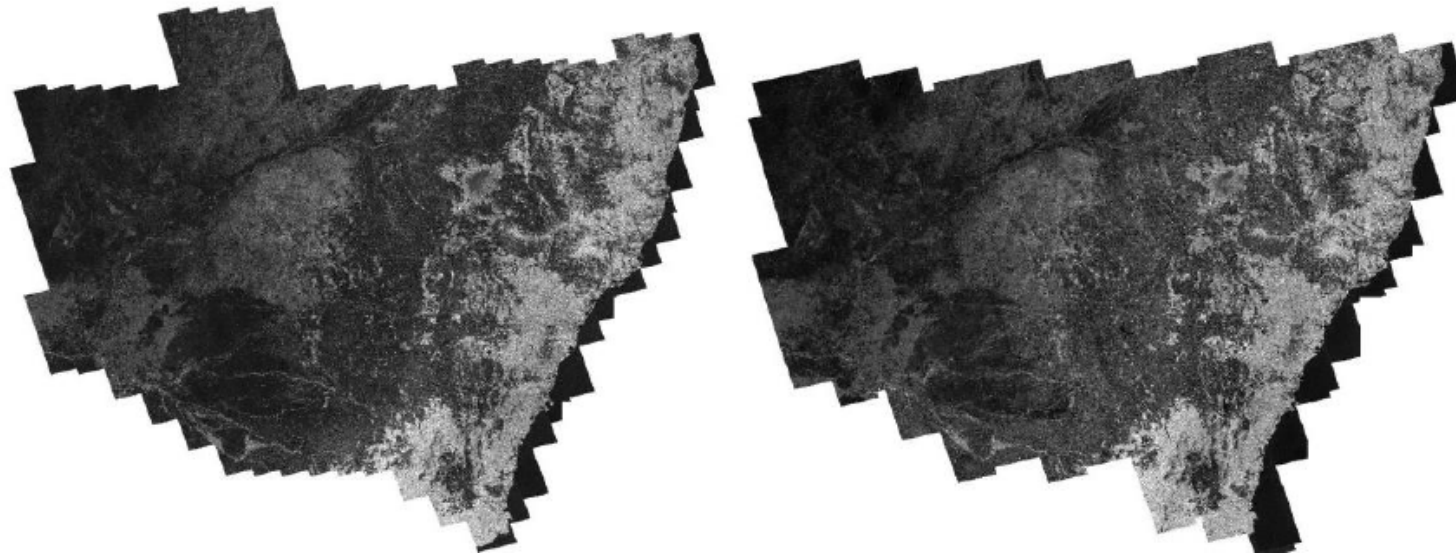
PALSAR-2 Mosaics for NSW



Internal matching of ALOS and ALOS-2 data to reduce spatial variations (both within and between swaths) of backscatter due to terrain and moisture.

Contact: Mark L. Williams
(mark.williams@physics.org)

PALSAR-2 Mosaics for NSW



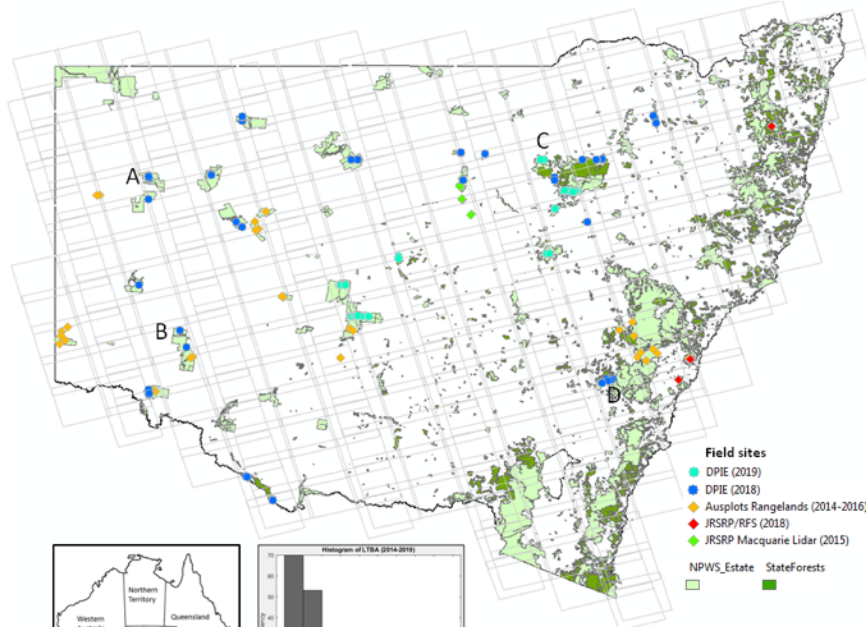
Internally matched ALOS-1 (left) and cross-matched ALOS-2 (right)

The cross-matching process places the two observation datasets (ALOS and ALOS-2) on a common footing to help in the subsequent estimation of changes in land cover and biomass. The combination of internal and cross-platform matching permits the use of generalized estimators for aboveground biomass.

Original data supplied by JAXA

Contact: Mark L. Williams (mark.williams@physics.org)

JRSRP Assessment of Regrowth and Biomass for NSW

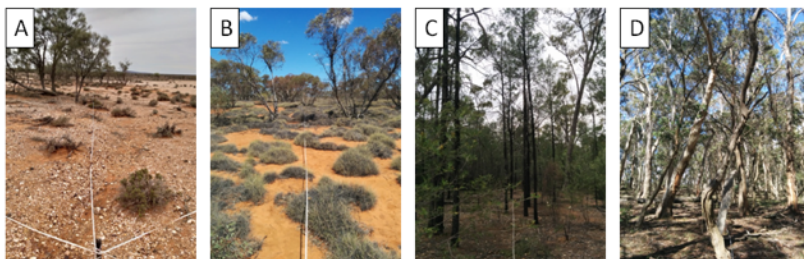


Use of basal area change as an indicator of regrowth in areas previously cleared, post-fire regeneration, plantings or growth in existing areas

- Allow tracking of areas of increasing woody vegetation across the State
- Feed into state-of-forest reporting

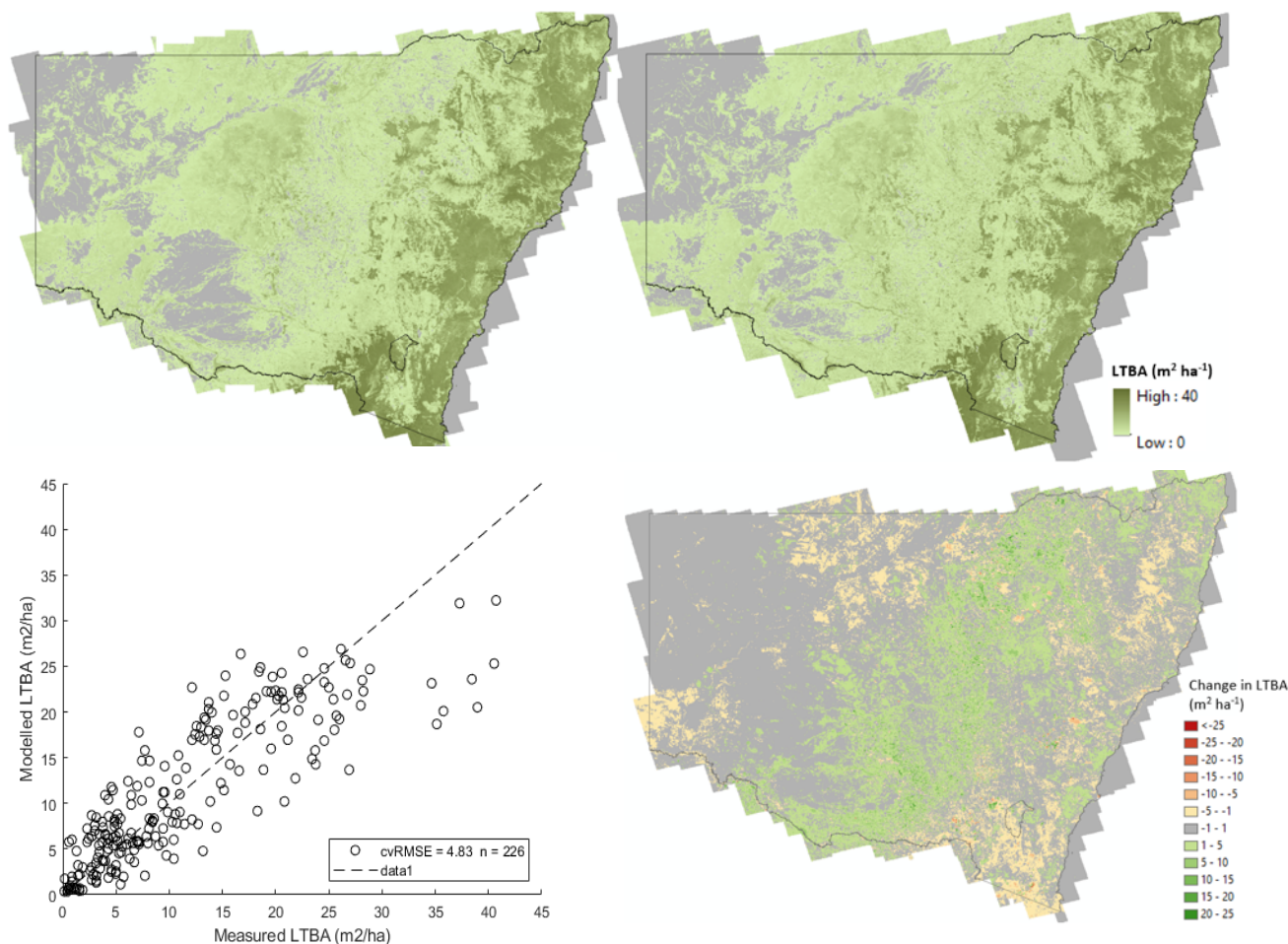
Location and frequency histogram of contemporary live tree basal area surveys (2014-2019).

- (A) Casuarina and Maireana sp. (bluebush) in semi-arid woodlands of western NSW
 (B) Mallee woodland in western NSW
 (C) Mixed eucalypt/callitris forest in NW NSW
 (D) Tall eucalypt forest in central tablelands



Contact: Anthea Mitchell (a.mitchell@unsw.edu.au)

JRSRP Assessment of Regrowth and Biomass for NSW



Live tree basal area (LTBA) estimates from ALOS (2009) and ALOS-2 (2016/17)

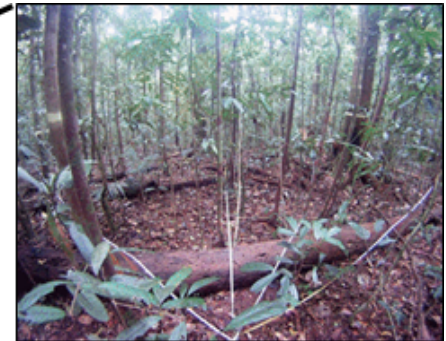
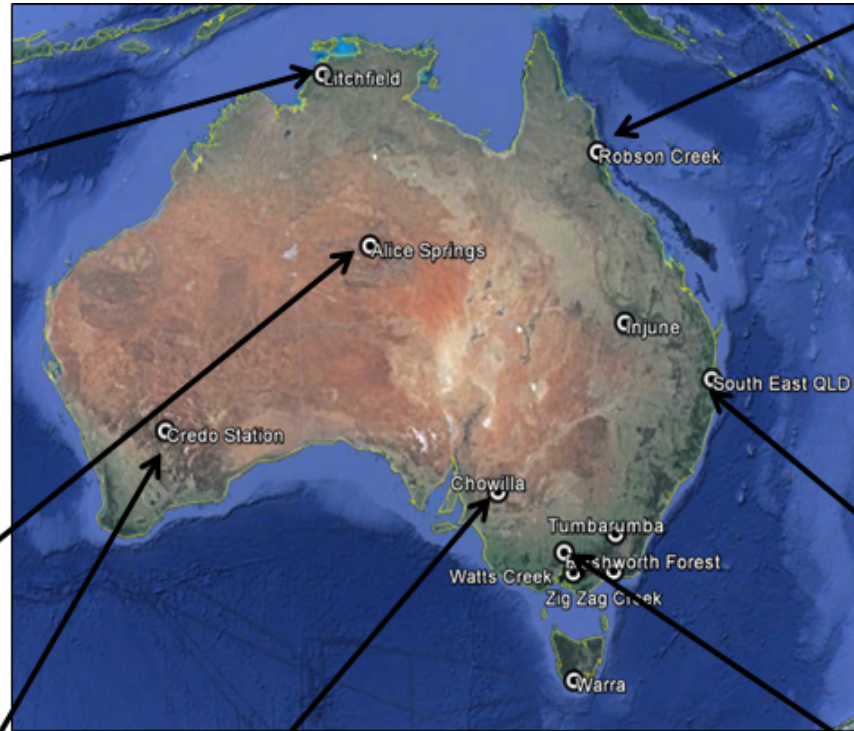
Change in LTBA obtained by differencing ALOS and ALOS-2 LTBA

Contact: Anthea Mitchell (a.mitchell@unsw.edu.au)

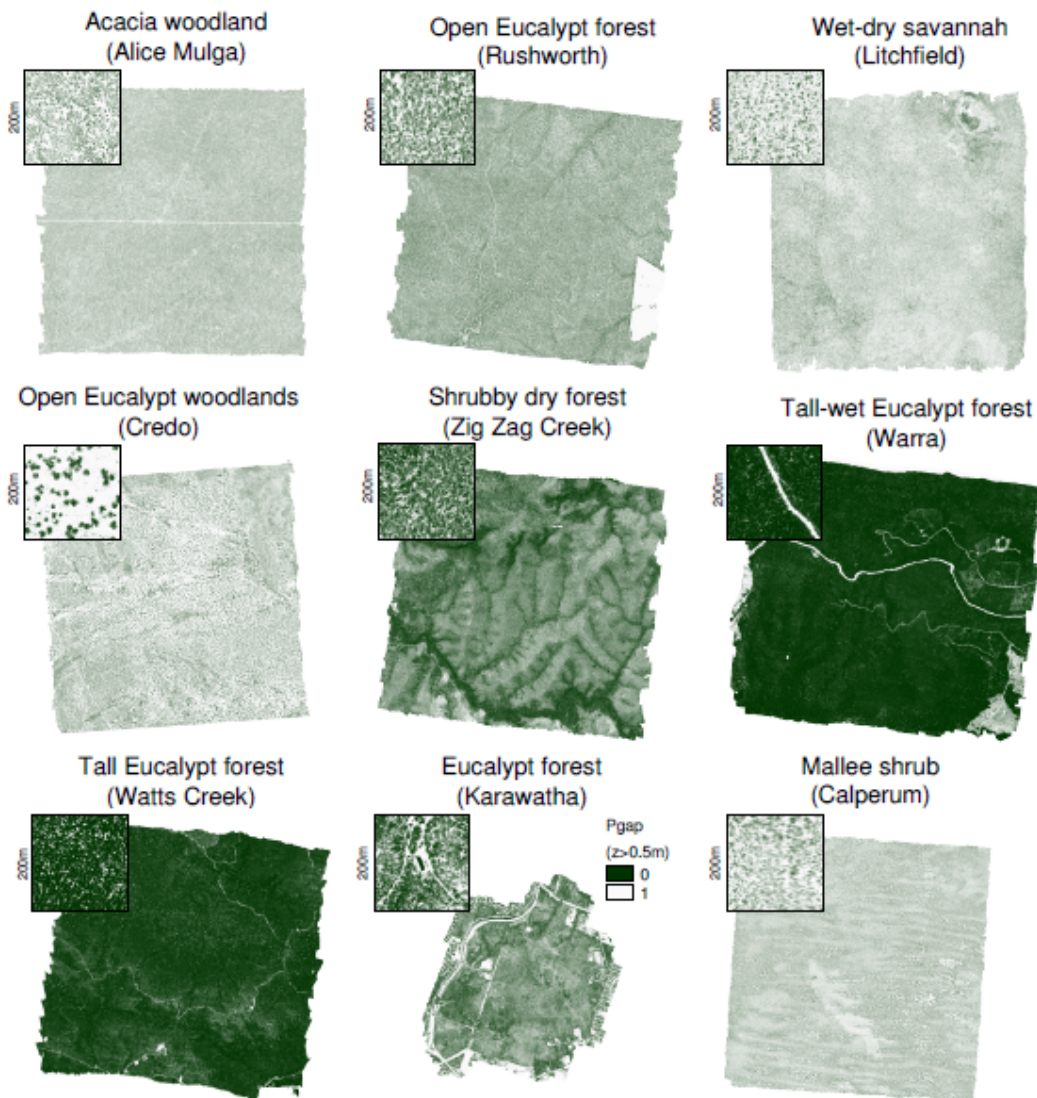
Post-K&C research objectives

1. Develop an approach for high resolution mapping of forest vertical structure and aboveground biomass for the 2019-2021 era using PALSAR-2 in combination with GEDI and ICESat-2
2. Quantify algorithm performance and the accuracy of demonstration products from (1) using updated reference data from TERN Landscapes supersites and the Australian Plant Biomass Library
3. Assess change in vertical canopy structure associated with degraded and regenerating forests using existing land cover change datasets
4. Evaluate the national (Australia-wide) implementation of (1) over the 2019-2021 era using JAXA L-band SAR, including the PALSAR-2 global mosaics

Study sites – TERN Landscapes SuperSites



Study sites – TERN Landscapes SuperSites



Focus on regenerating and degraded forests at TERN SuperSites

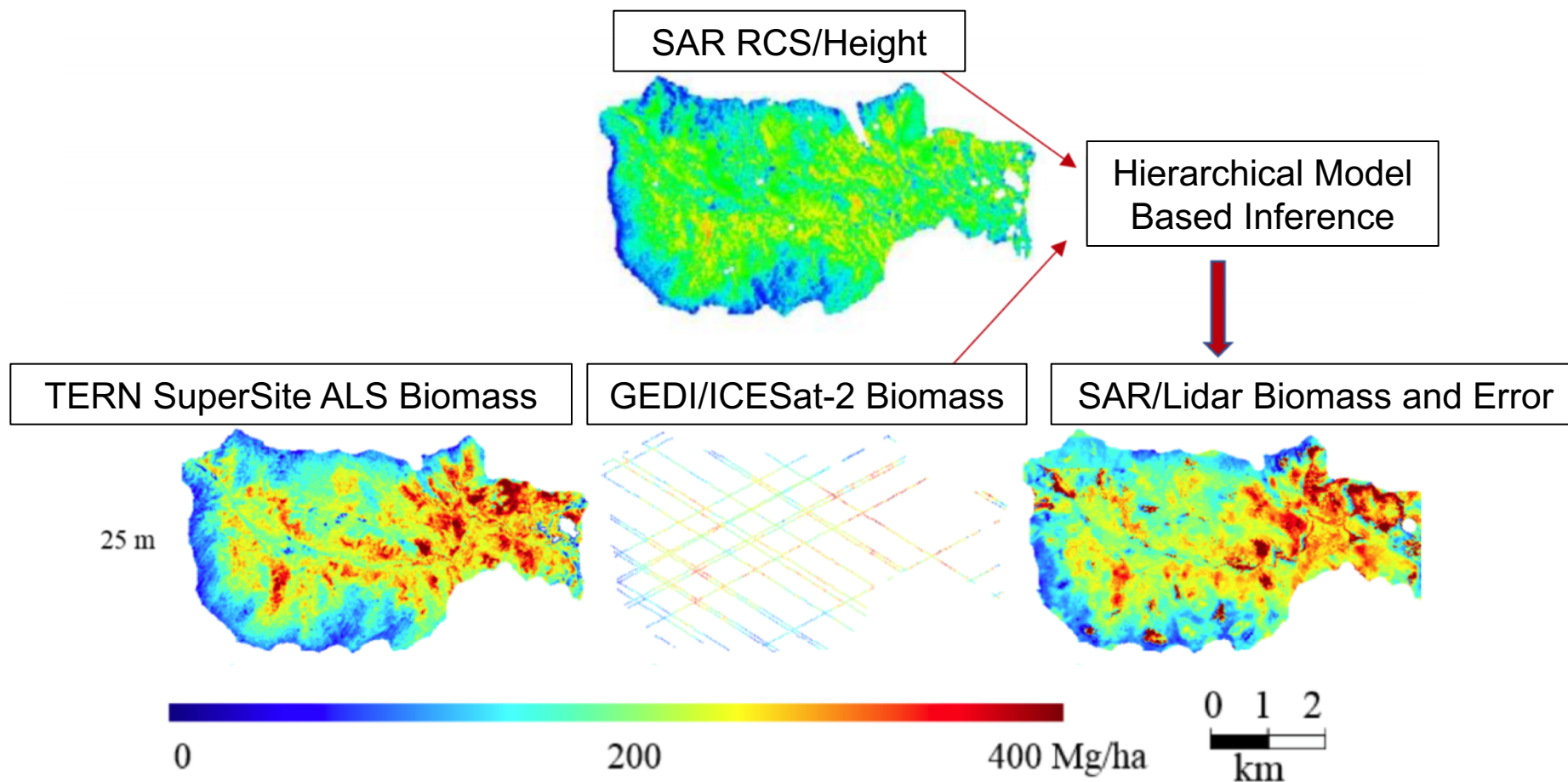
Regrowth following clearing:

- Injune Landscape Collaborative Project

Fire disturbance:

- Calperum (January 2014)
- Warra (January 2019)
- Litchfield (May 2018)
- Tumbarumba (December 2019)

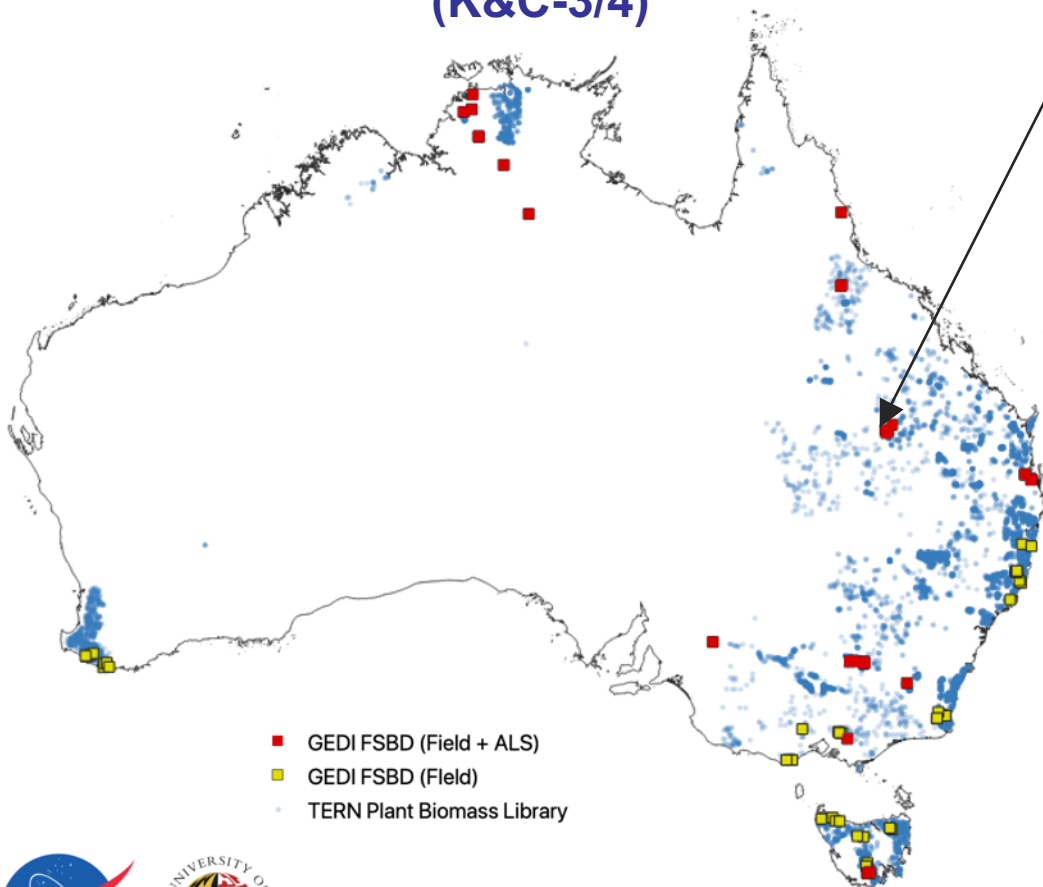
Proposed approach for research objectives 1 & 2



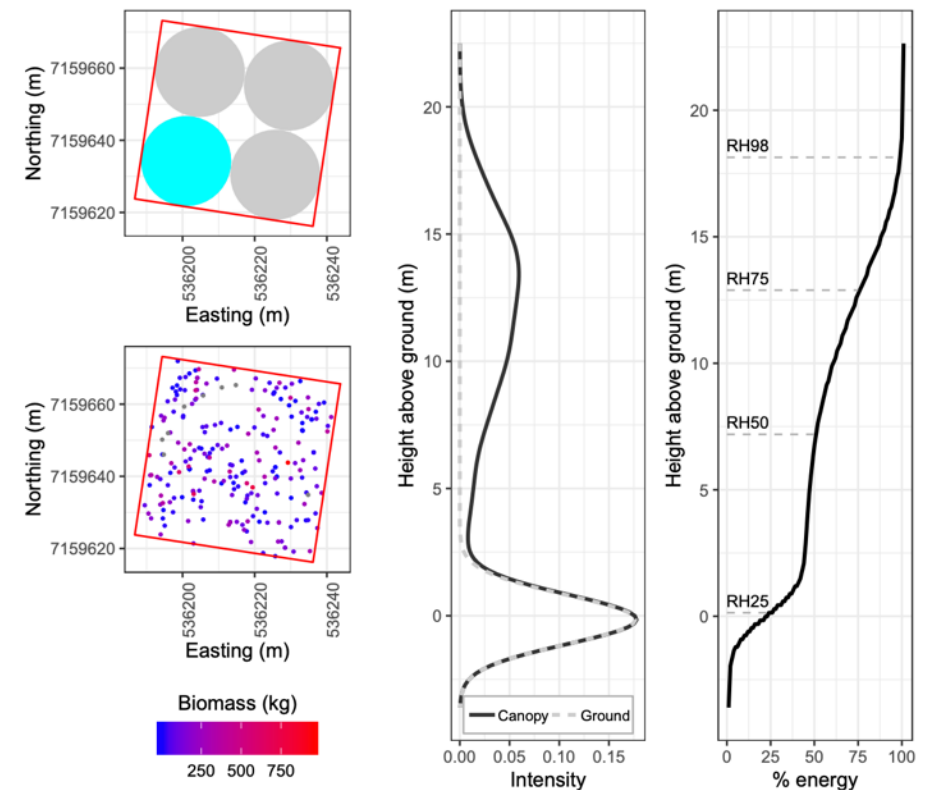
Adapted from: Qi, W., Saarela, S., Armston, J, Ståhl, G , G. & Dubayah, R. O. (2019) Forest biomass estimation over three distinct forest types using TanDEM-X InSAR data and simulated GEDI lidar data. *Remote Sensing of Environment*, 232: 111283.

GEDI lidar aboveground biomass estimators

Filtering of the TERN Plant Biomass Library (K&C-3/4)



Injune Landscape Collaborative Project



GEDI and ICESat-2 observations (2019 – 2021)

Coverage Laser

Full Power Laser

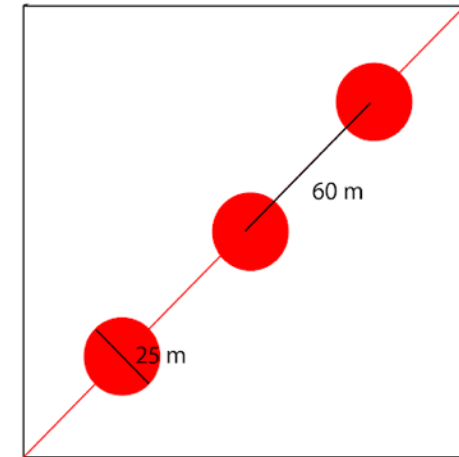
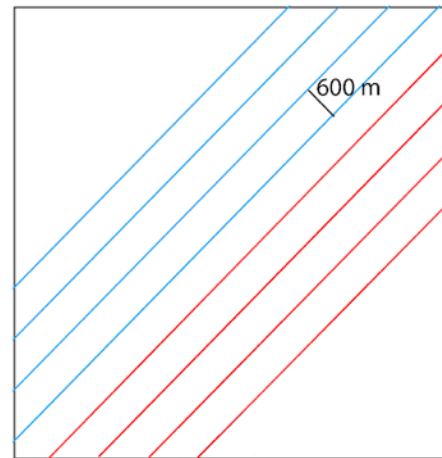


Coverage Laser

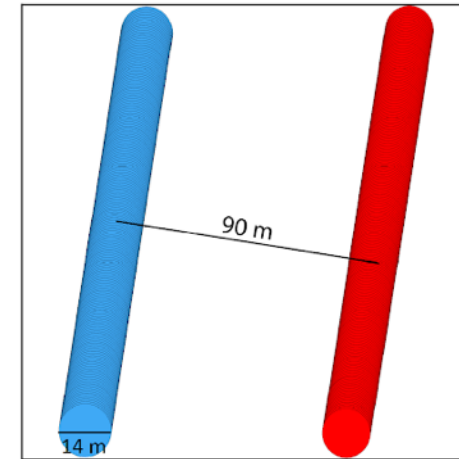
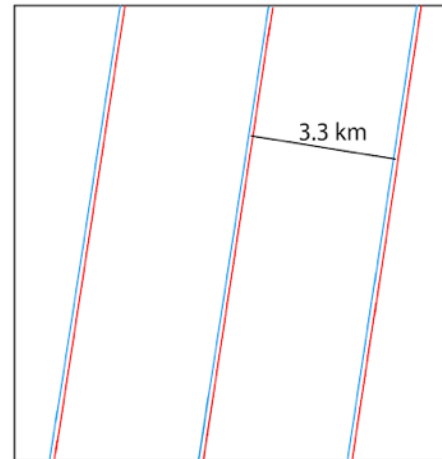
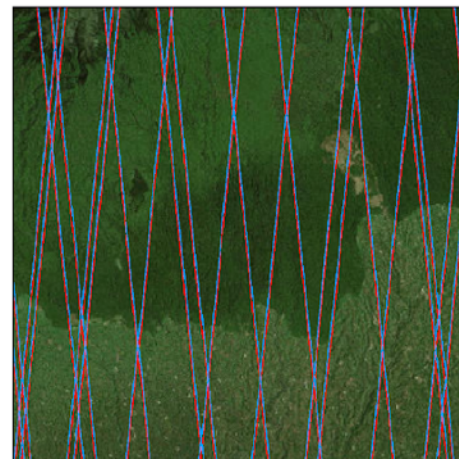


Full Power Laser

GEDI



ICESat-2



0 5 10 Kilometers

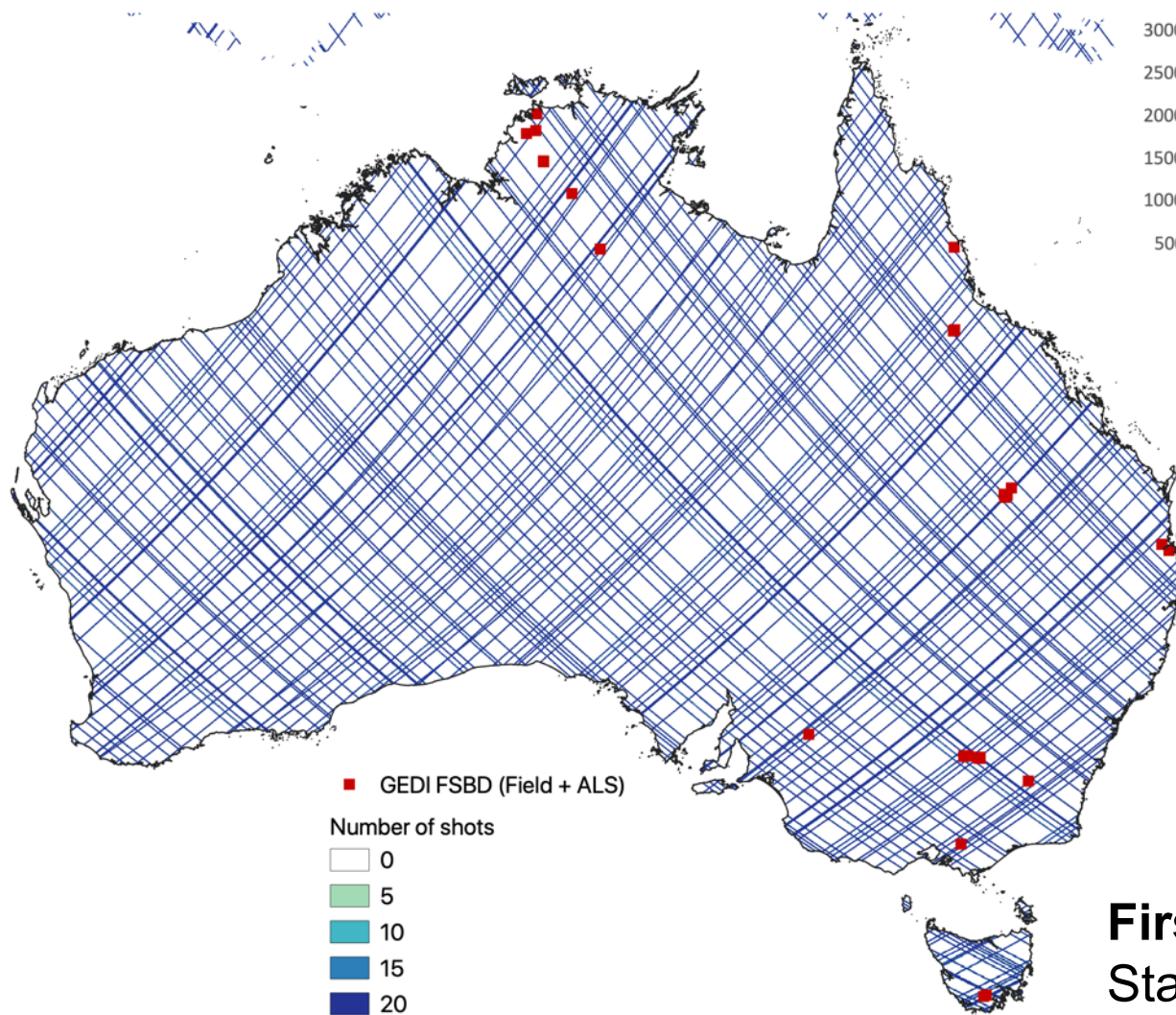
0 1 2 3 4 km

0 15 30 45 60 m

ALOS

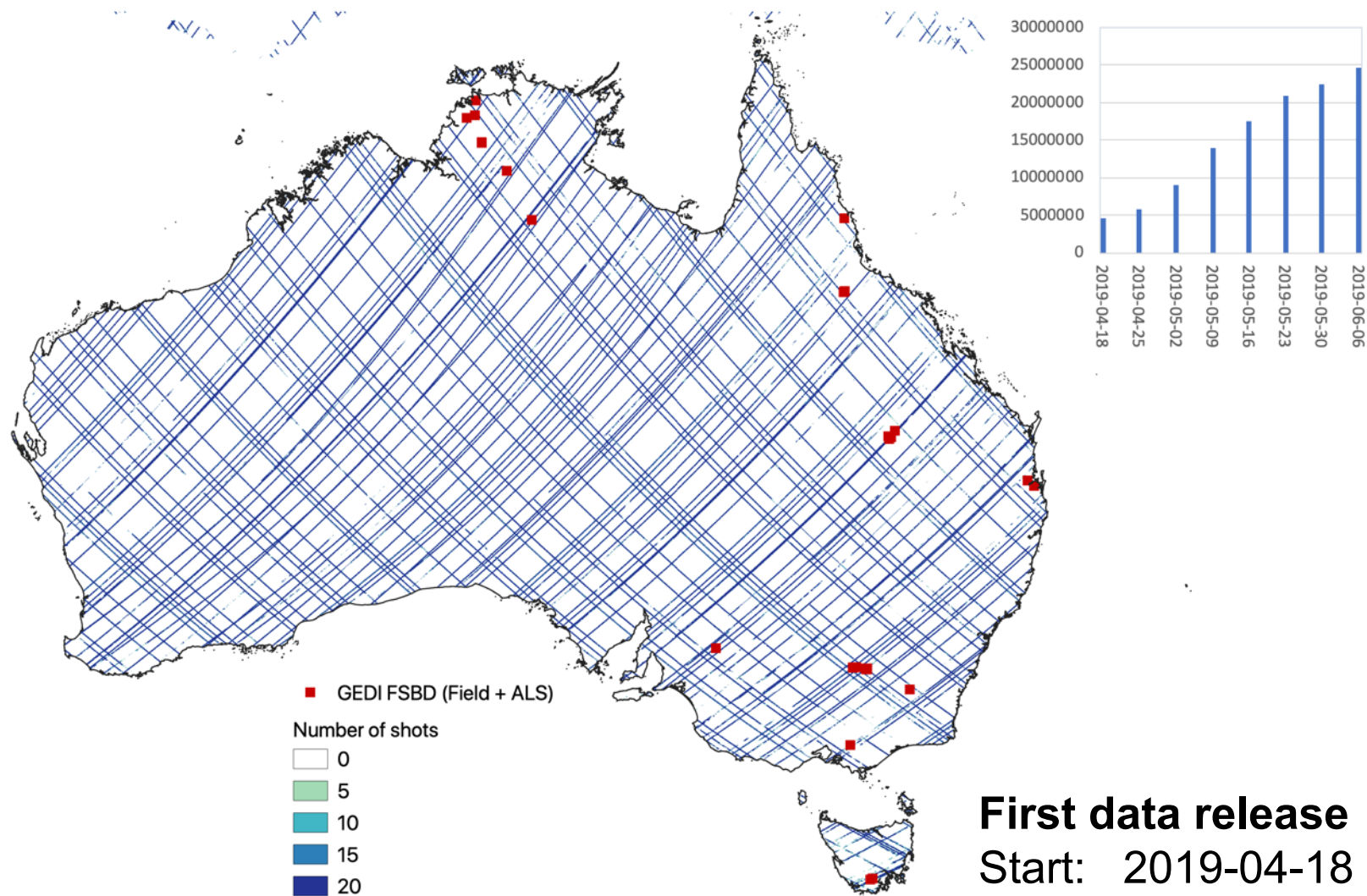
K&C Initiative
An international science collaboration led by JAXA

Land observations

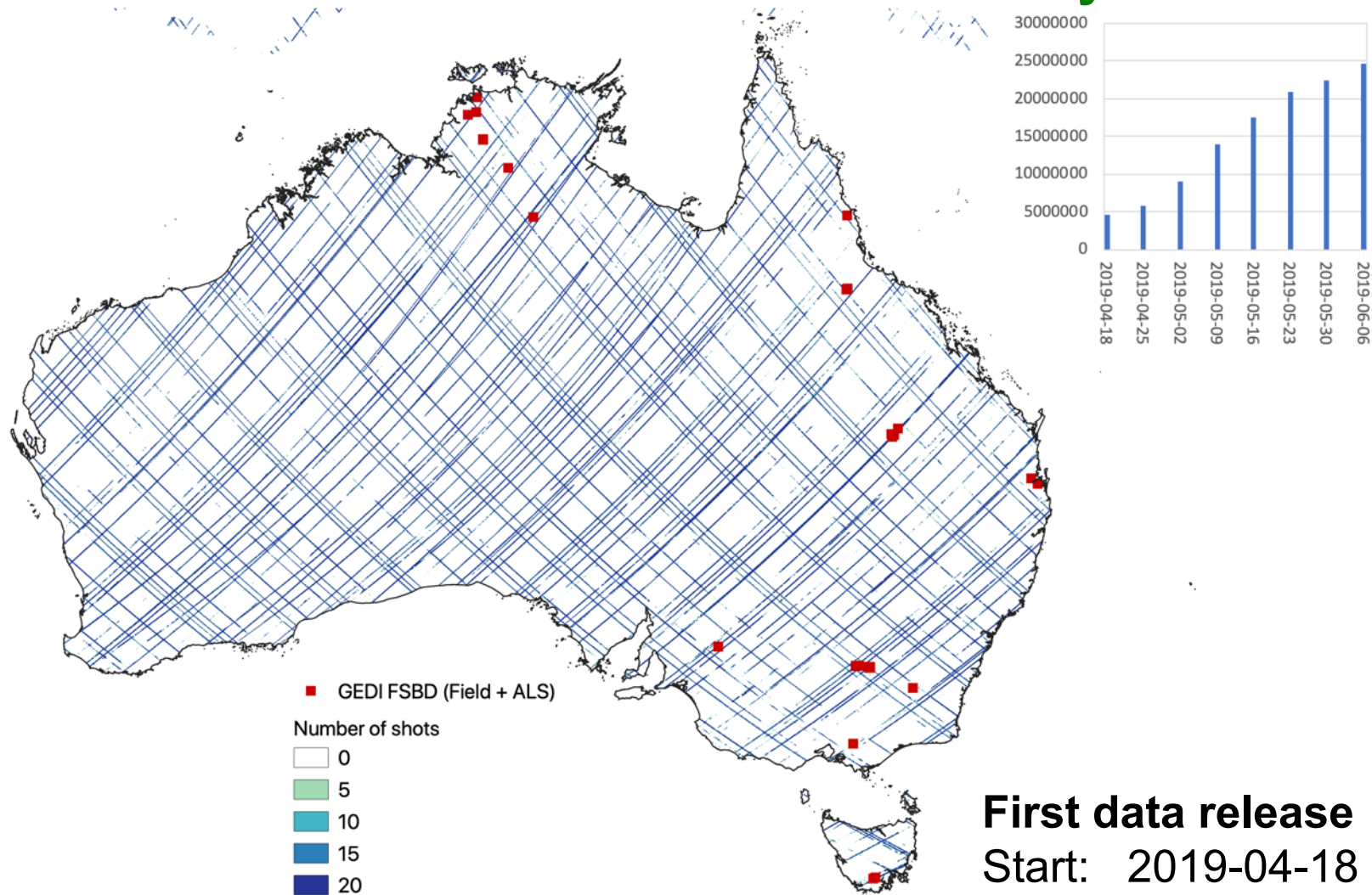


First data release
Start: 2019-04-18
Finish: 2019-06-12

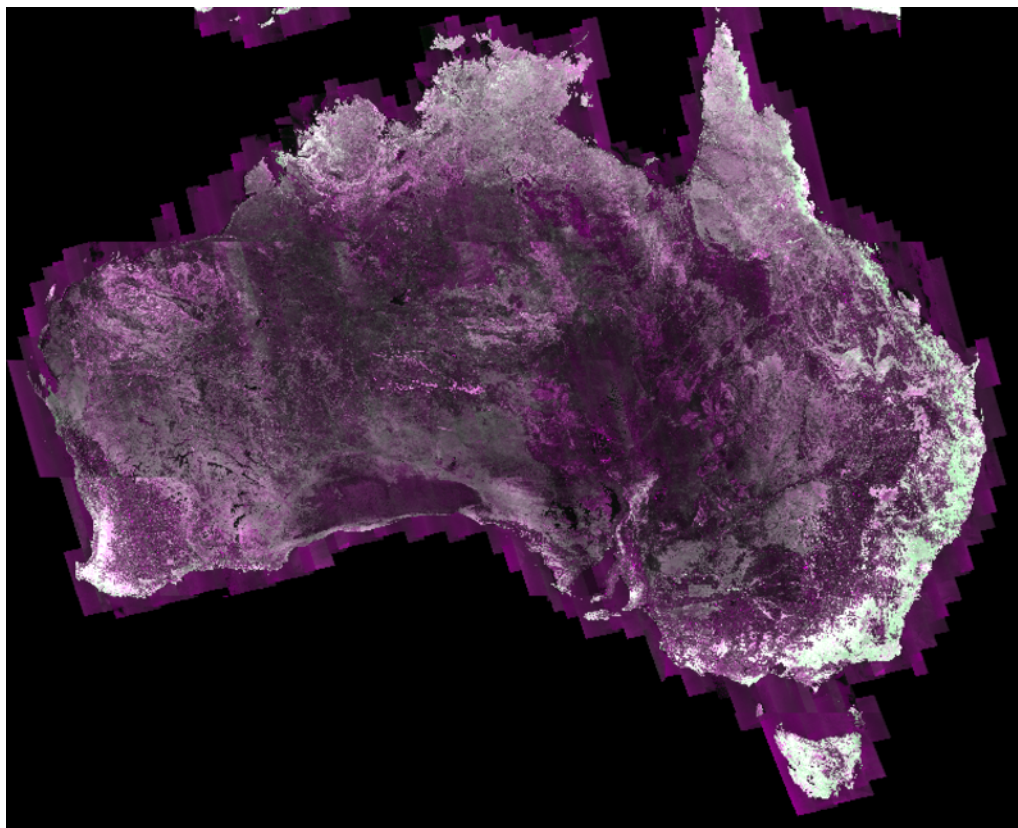
Land surface observations



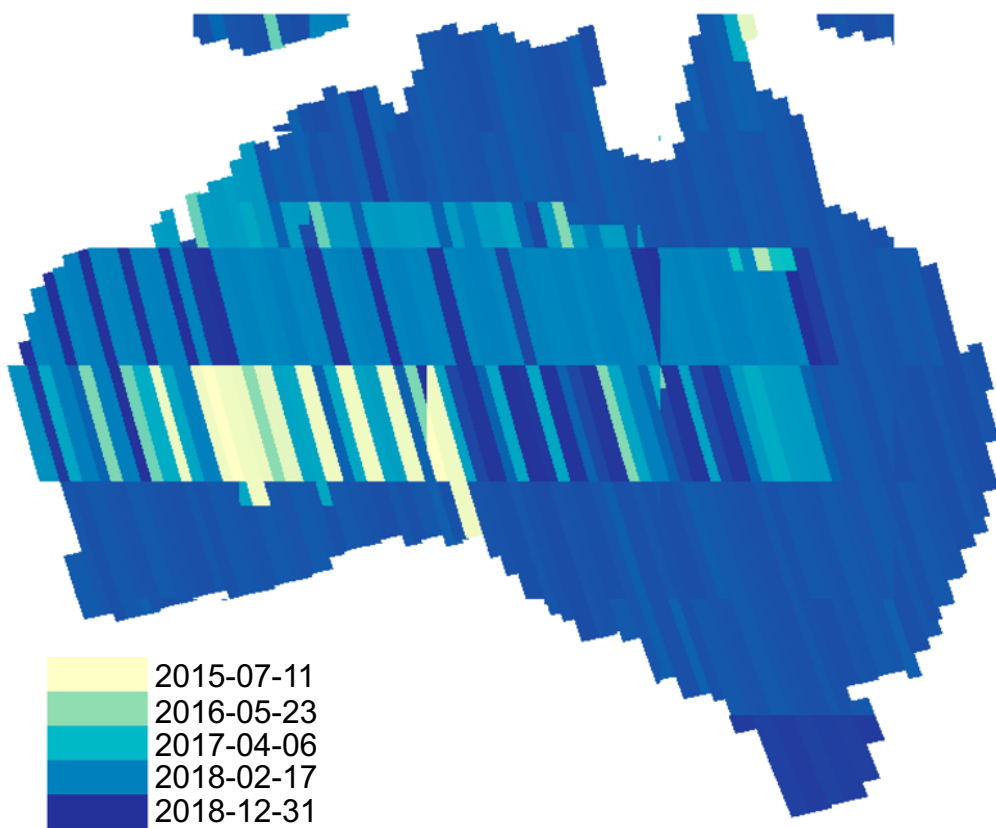
Land surface observations > 95% sensitivity



JAXA 2018 PALSAR-2 Australian Mosaic



L-HH | L-HV | L-HH



2015-07-11
2016-05-23
2017-04-06
2018-02-17
2018-12-31

Acquisition Date

Deliverables and other output

1. Peer-reviewed publication on efficacy of GEDI and ICESat-2 for reducing uncertainty in L-band SAR mapping of aboveground biomass mapping in Australian forests and woodlands
2. Demonstration high spatial resolution height and aboveground biomass data products over TERN Landscapes SuperSites
3. Publication of open field/lidar data pairs through the NASA/ESA MAAP (Australian component under auspices of TERN and K&C)
4. Peer-reviewed publication and data product on 2019-2021 Australian vertical plant profile metrics and their changes across degraded (fire impacted) and regenerating forests
5. Non-peer-reviewed publications (e.g., post-K&C reports)

PALSAR/PALSAR-2 data access

Post-KC PALSAR/PALSAR-2 data requested:

- TERN SuperSites (fire impacts a priority)
- Cycles 137 to 139 (Oct – Nov 2019)

Post-KC PALSAR/PALSAR-2 data obtained:

- None

Data availability limitations:

- Post-fire over Eastern Australia sites (particularly NSW)
- No FBD scheduled in BOS Dec 2019 – Apr 2020 (Cycle 140 – 150)
- ALOS-2 “Super-Super site”?



**Tumbarumba
TERN Supersite
Credit: NSW FC**

Acknowledgements

- Jim Kellner, Laura Duncanson, Wenlu Qi and Ralph Dubayah
(GEDI Science Team)



- Mark Williams (HGC) and Tim Danaher (NSW Government)



Post-K&C – First Report

Fusion of ALOS-2 and Spaceborne Lidar Observations for High Resolution Mapping of Degraded and Regenerating Forest Structure and Biomass in Australia

John Armston^{1,2}

Peter Scarth², Anthea Mitchell^{3,2}

Oliver Cartus⁴, Richard Lucas⁵

¹ University of Maryland

² JRSRP, University of Queensland

³ University of New South Wales

⁴ Gamma Remote Sensing

⁵ University of Aberystwyth