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K&C Phase 4 – Status report

Forest characterization and monitoring in Tasmania, Australia, using ALOS-1/2 PALSAR data in support of national forest monitoring systems

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UNSW THE UNIVERSITY OF NEW SOUTH WALES

Science Team meeting #24
Tokyo, Japan, January 29-31, 2018

MACQUARIE University SYDNEY·AUSTRALIA

Project context

- Robust, comparable & sustainable NFM and carbon accounting demands an accurate baseline and spatio-temporal information on F and LC
- Demonstrate an approach to forest information product generation in Tasmania, Australia, to support state-wide planning & conservation
- Traditional NFMS reliant on optical data
  - Familiarity, access, time-series
- SAR prominence over last decade
  - Differing sensitivity and imaging capabilities
  - Synergistic use offers new level of detail
  - Upcoming launches
  - SAR applications in forest resource management
    - Wall-to-wall NFMS for better tracking of longer term trends

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Project objectives

- Generate forest thematic products considered useful for NFMS
  - GFOI review (2013)
  - Extend on previous work undertaken in GEO Forest Carbon Tracking task
  - Support K&C thematic drivers
    - C cycle science, intern. conventions, environ. conservation

IPCC category	GFOI thematic map product	Description
Land use and change	All land use categories	Default UN FAO Land Cover Classification (LCCS) or equivalent national classification
	Land use change between forests and other land uses	Maps of conversions between the 6 IPCC land categories (activity data)
Forest area and change	Forest/non-forest cover	Maps of forest cover through time
	Forest cover change	Maps of change in area of forest land
	Near-real time forest change indicators	Useful for early warning and detection of forest clearing and degradation
Forest remaining forest	Forest stratification	Forest stratified according to natural, plantation and relevant forest types
	Degradation type	Maps of forest degradation types and proxies/indicators of degradation
	Degradation (and enhancement of C stocks)	Mapping of biomass/carbon loss or gain, or change in other vegetation metric relative to a reference year
	Above ground biomass (AGB) estimates	Maps showing vegetation biomass estimates
	Change in AGB	Map showing changes in vegetation biomass estimates

- Demonstrator products:
  - Calibrated SAR mosaics
  - Forest and land cover
    - Interoperability and complementarity of C- and L-band SAR and optical data
    - PolSAR/PolInSAR analysis
  - Forest cover change
    - Evaluate performance of ALOS-1/2 PALSAR and Sentinel-1A time-series
  - Regrowth forests
    - C- and L-band SAR
  - Above ground biomass estimates
    - L-band SAR and LiDAR

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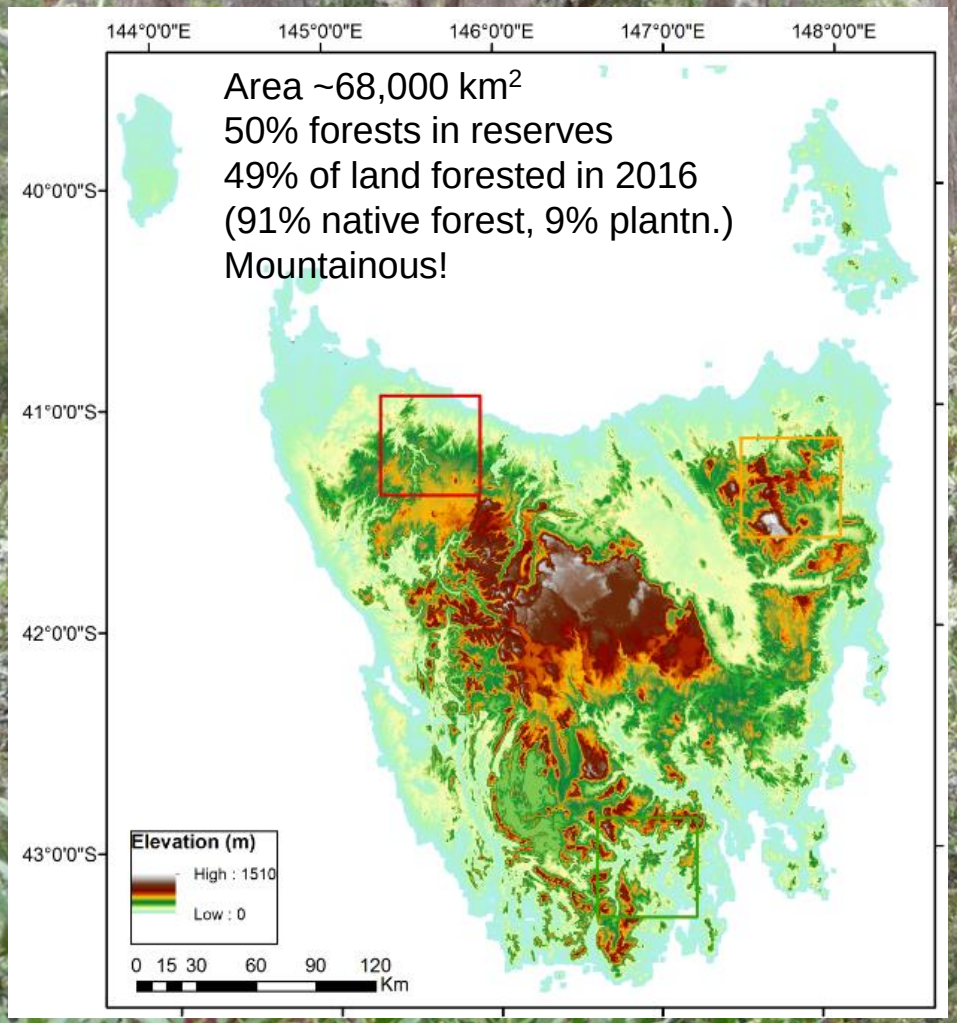
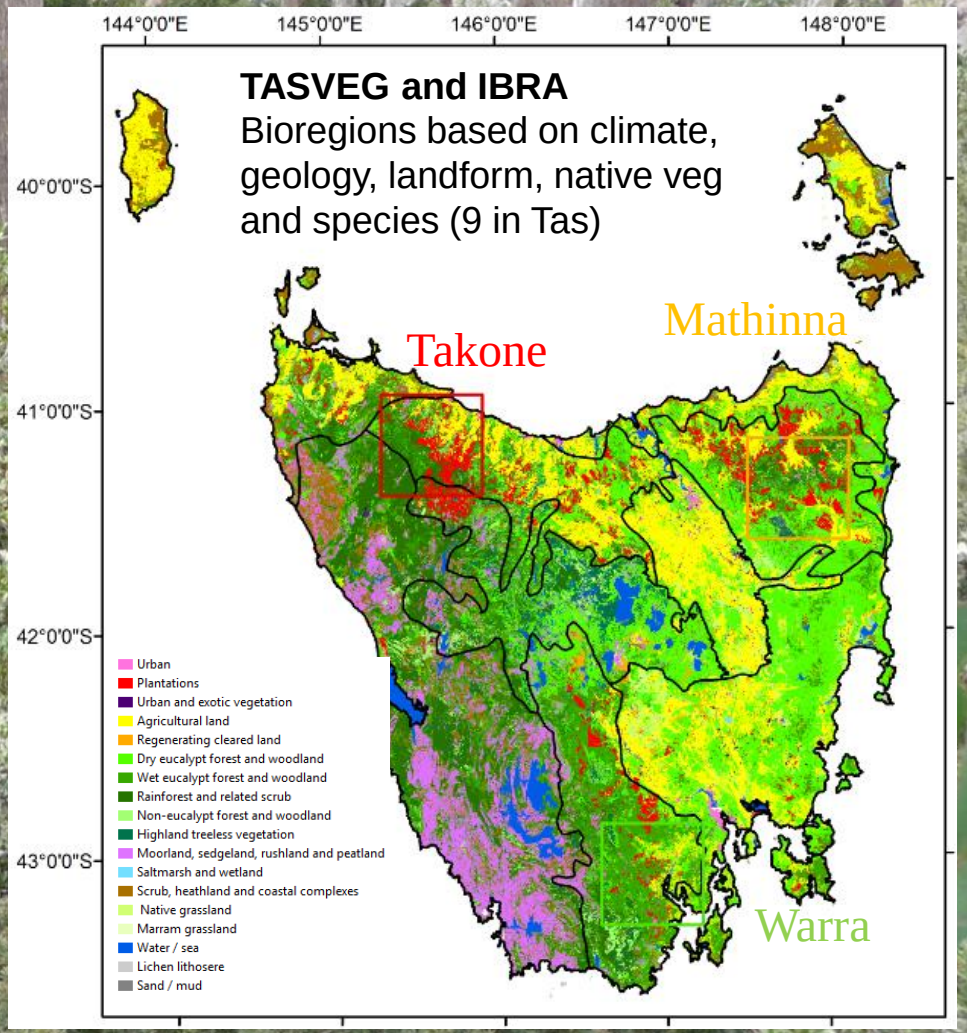
Tasmania, Australia





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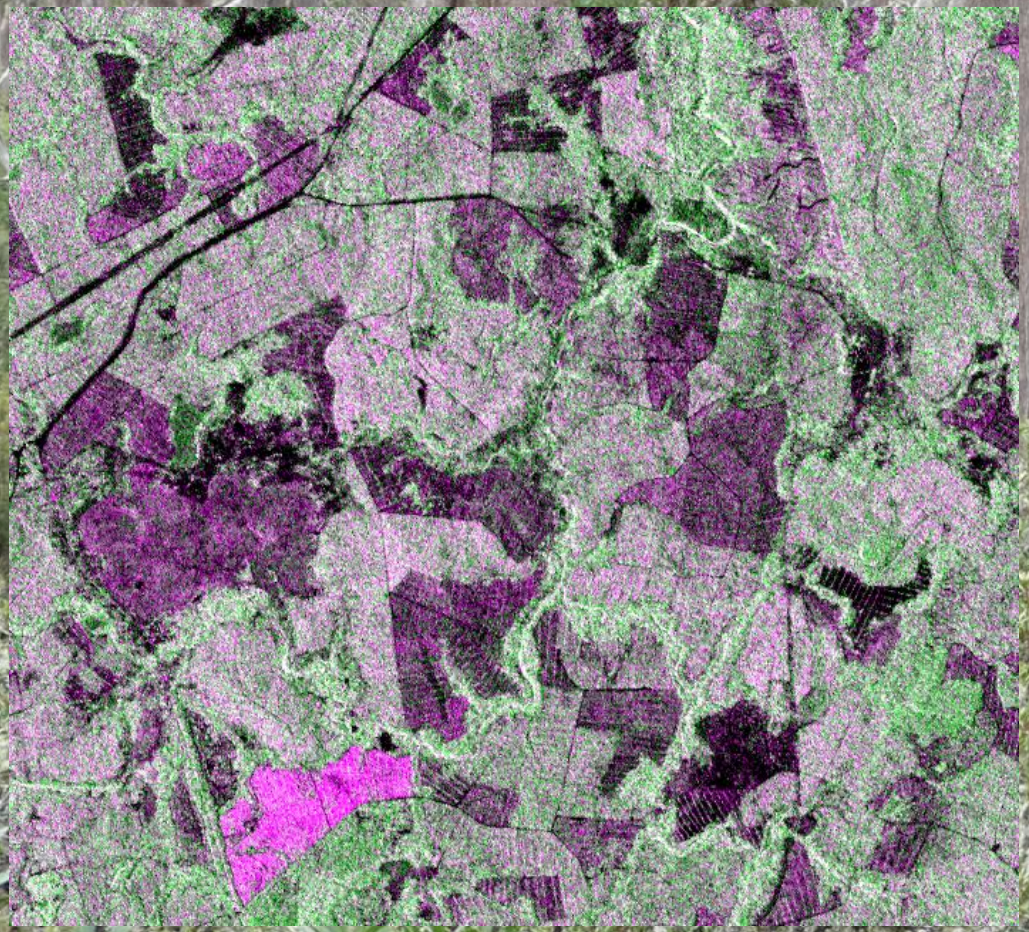
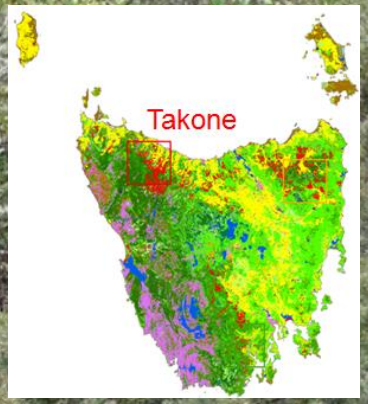


Eucalypt plantations

Wet euc & Rainforest



Detail of plantation near Takone
Northern slopes bioregion
Heavily forested, active forestry & agriculture

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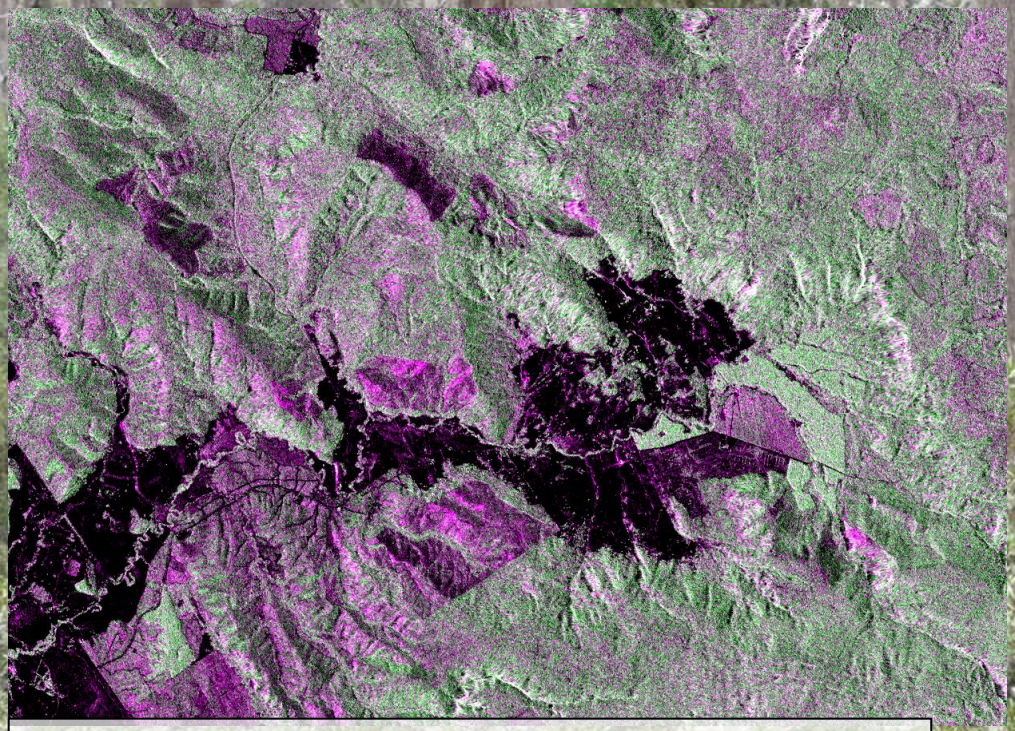
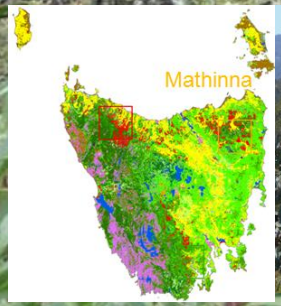
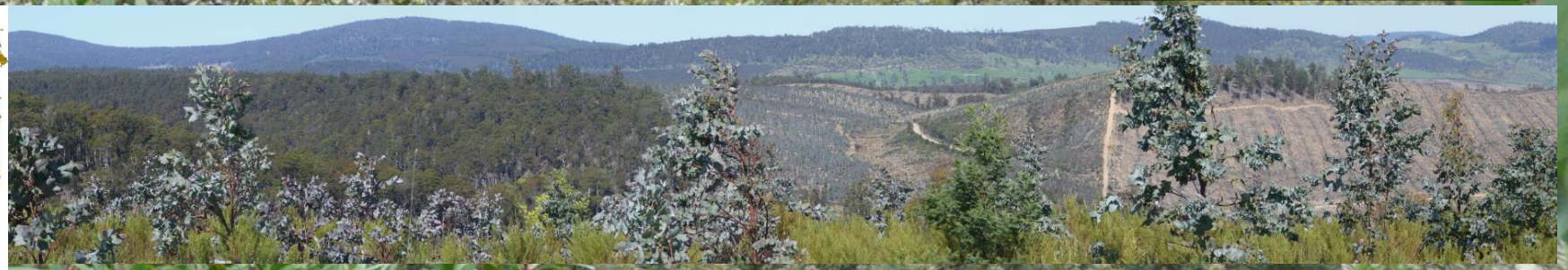


Plantation and agriculture, Mathinna
Ben Lomond bioregion

Buttongrass &
tea tree swamp

Manna gum forest





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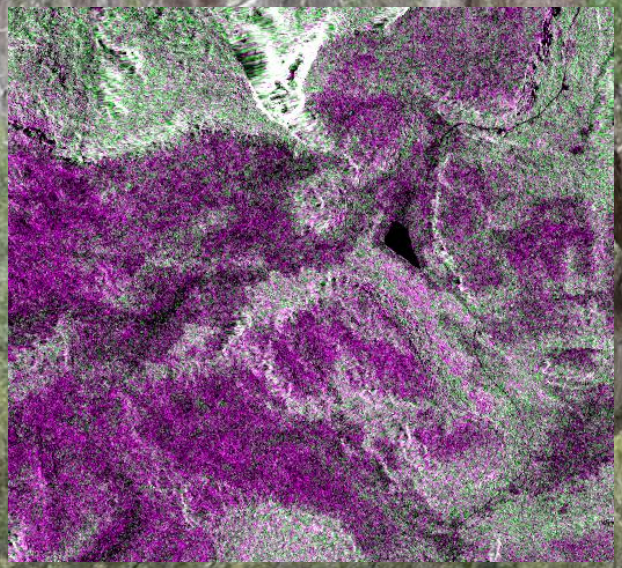
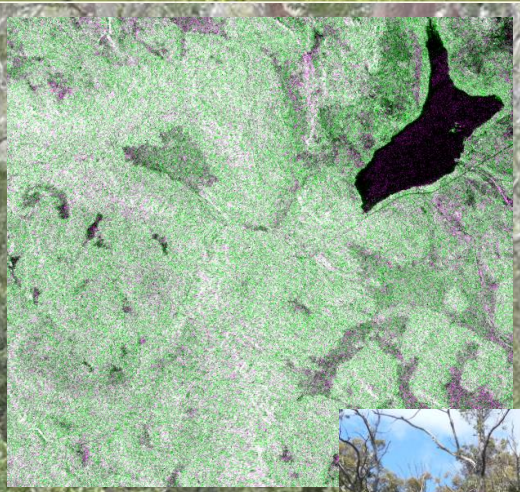
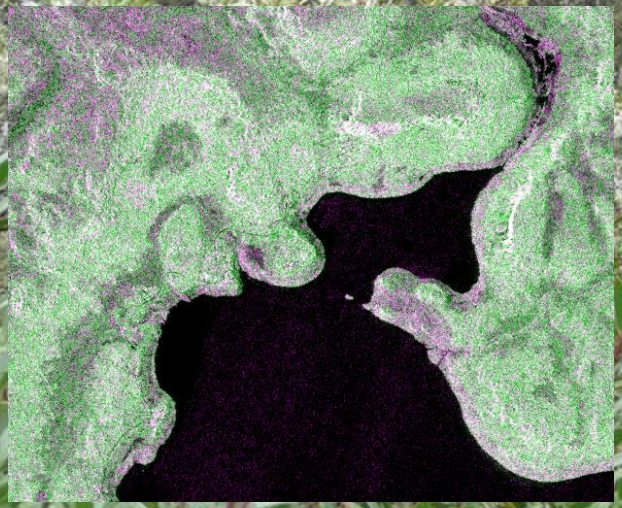


Pine lake, alpine scrub

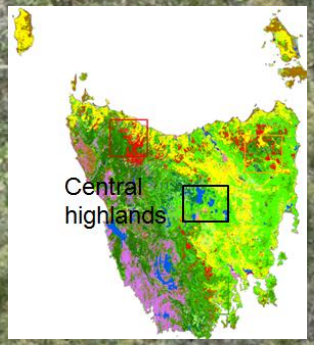


Dry euc forest

Great lakes, central highlands

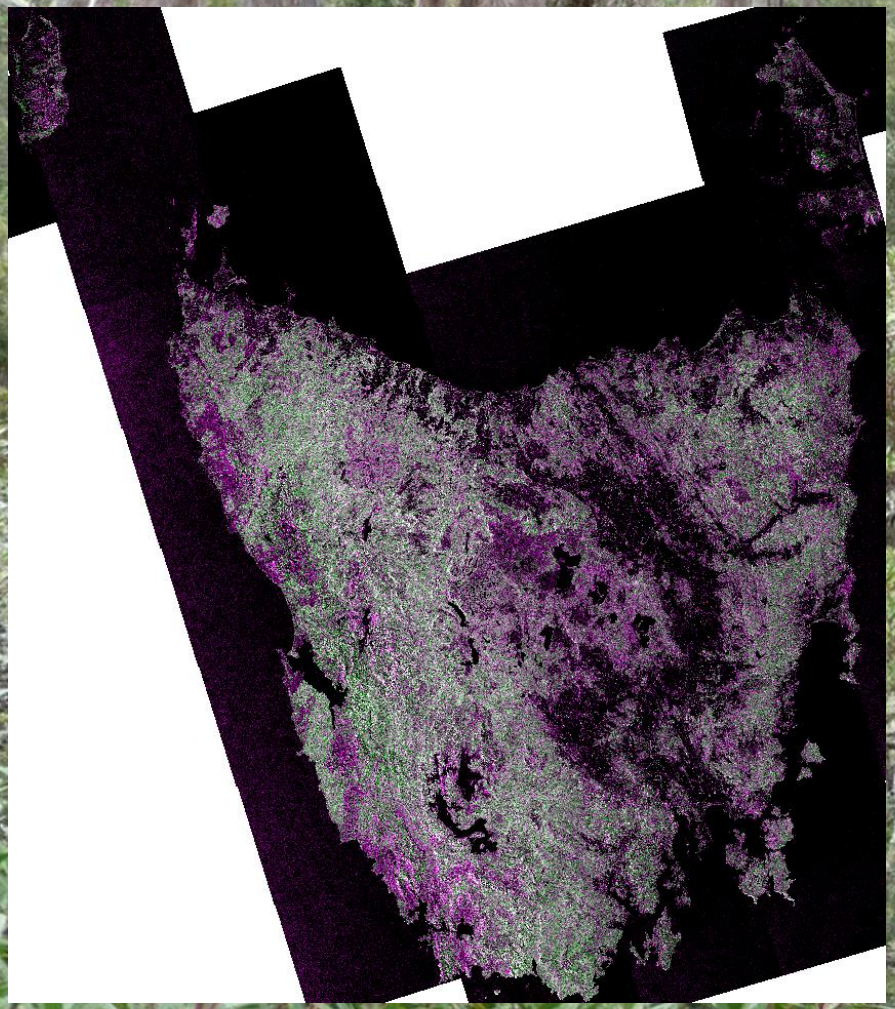


View to Great lake



Eucalyptus delegatensis
Selectively logged in past

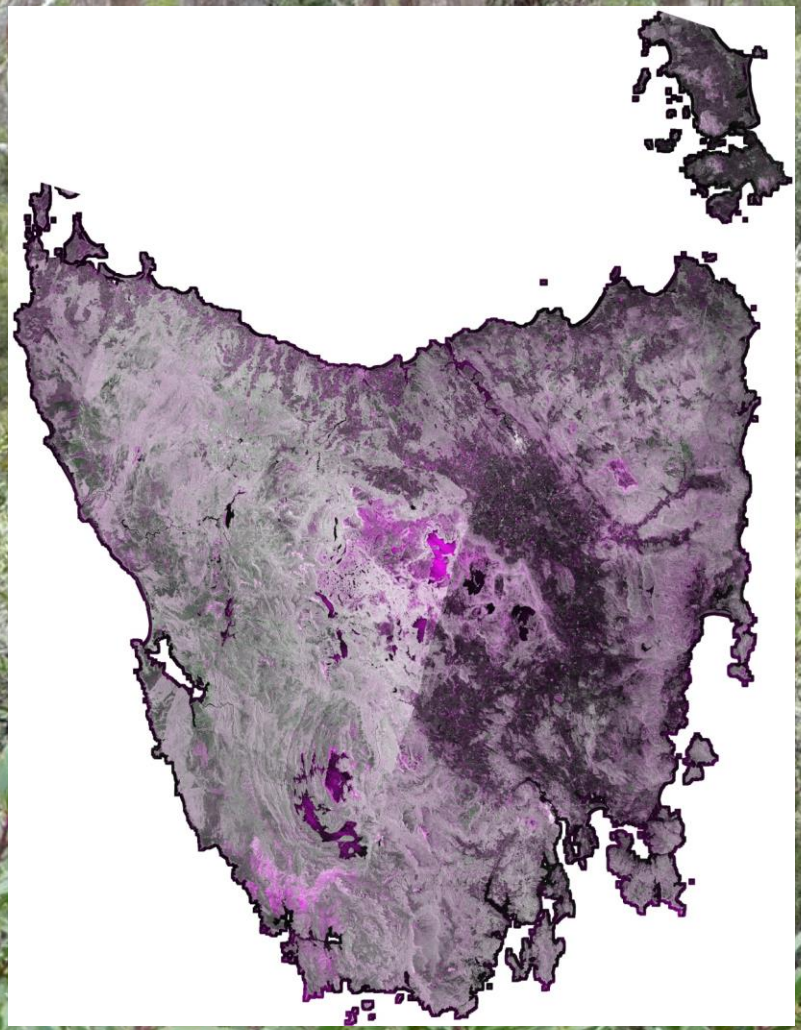
Results: Calibrated ALOS-2 PALSAR-2 mosaic



- Processing of PALSAR-2 L1.1 to Analysis Ready Data (ARD)
- SM3 (HH+HV), Asc., R looking
  - 37 images Sept-Oct 2015
- Processing chain implemented in SARscape
  - Multilooking, lee filter, geocoding using 25 m DEM and RadCal
    - Layover/shadow maps
    - Sigma0 dB
    - 12.5 m grid size
  - Mean pixel mosaicking

ALOS-2 PALSAR-2 2015 mosaic
HH:HV:HH in RGB

Calibrated Sentinel-1A mosaic

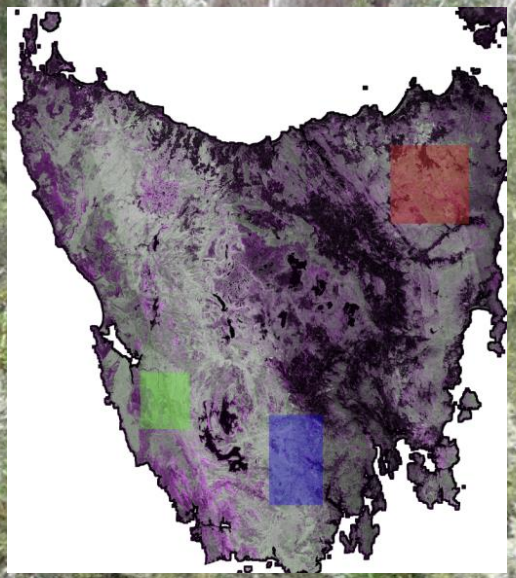


- IWS mode (VV+VH), Desc. orbit, R looking
  - 5 images acquired in Oct 2015
- IWS, Asc. orbit, R looking
  - Dense time-series over Warra
  - 9 images Jan-Oct 2015
- Prior processing of SAR L1 images to ARD
  - Geocoding, radcal, terrain correction
    - Layover/shadow maps
    - Sigma0 dB
    - 12.5 m grid size

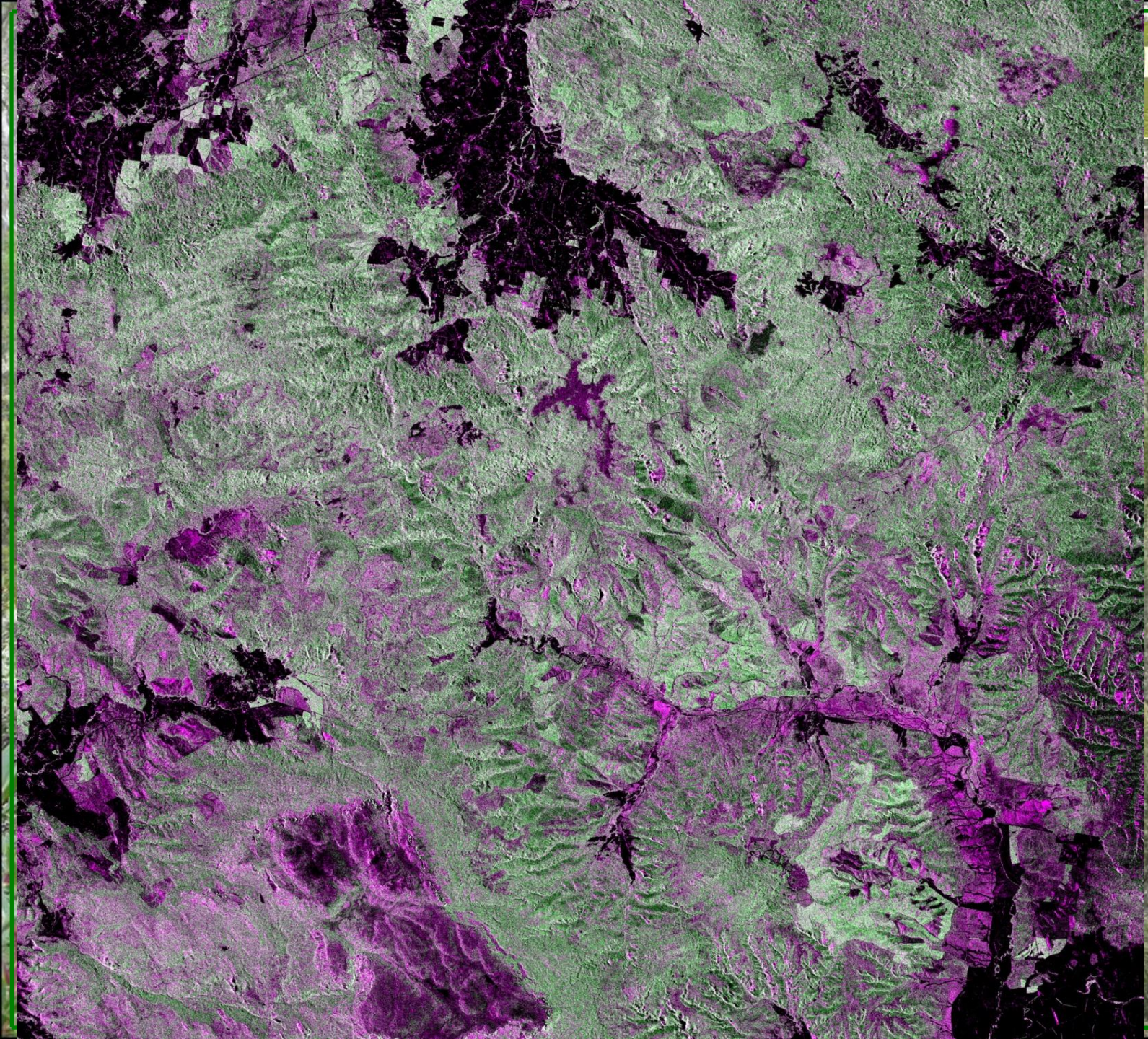
Sentinel-1A 2015 mosaic
VV:VH:VV in RGB

Forest and land cover

- Demonstrated for 2 study sites
- Object-based classification of land cover
  - Kmeans clustering (RSGISLIB)
  - Feature extraction
    - Spectral, texture, topographic
    - Separability analysis of land covers
  - Local training using TASVEG and plantations
  - SVM classification
    - SAR-only model (ALOS-2, Sentinel-1A)
    - Optical-only model (Landsat-8)
    - Combined
  - Validation
- Merge to produce forest/non-forest maps



Location of study sites: site 1 (red), site 2 (green), site 3 (blue)



Site 1

ALOS-2 PALSAR-2 HH:HV:HH in RGB

Sentinel-1A VV:VH:VV in RGB

Landsat-8 NIR:Red:Blue

SVM classification of Land cover (12)

Forest/Non-forest

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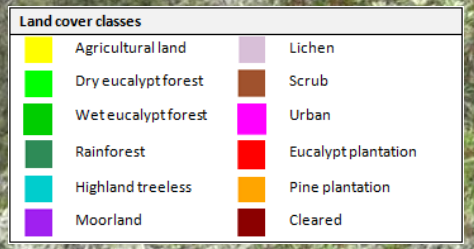
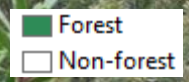
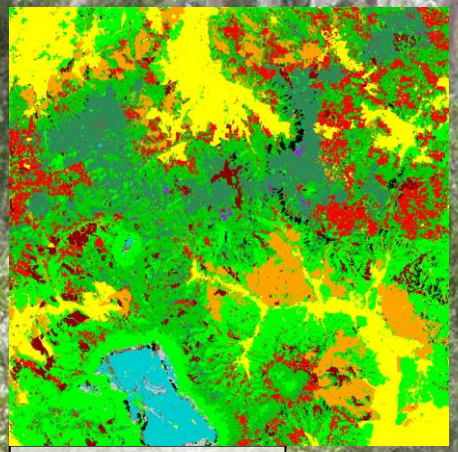
Land cover and F/NF: Site 1

- Good correspondence with TASVEG
- Classification accuracy improved when using combined SAR and Optical model
  - Mapping improvements in plantation, cleared and alpine areas

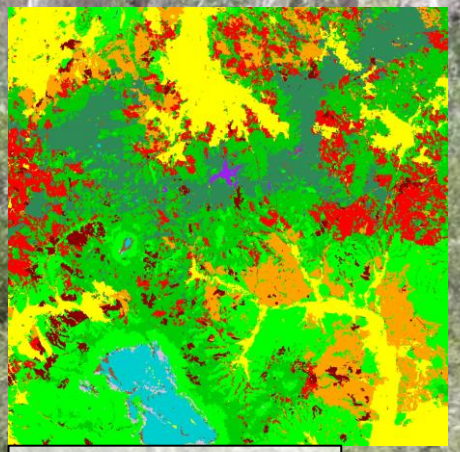
SVM - Input dataset	Accuracy (%)
Land cover	
All input layers	81.1
SAR only	67.9
Optical only	80.6
Forest/Non-forest	
All input layers	98.0
SAR only	97.4
Optical only	97.5



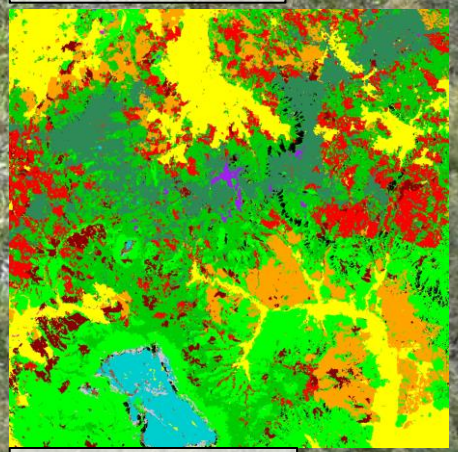




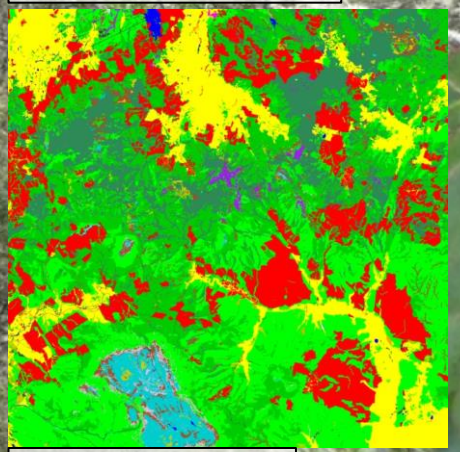
SAR-only



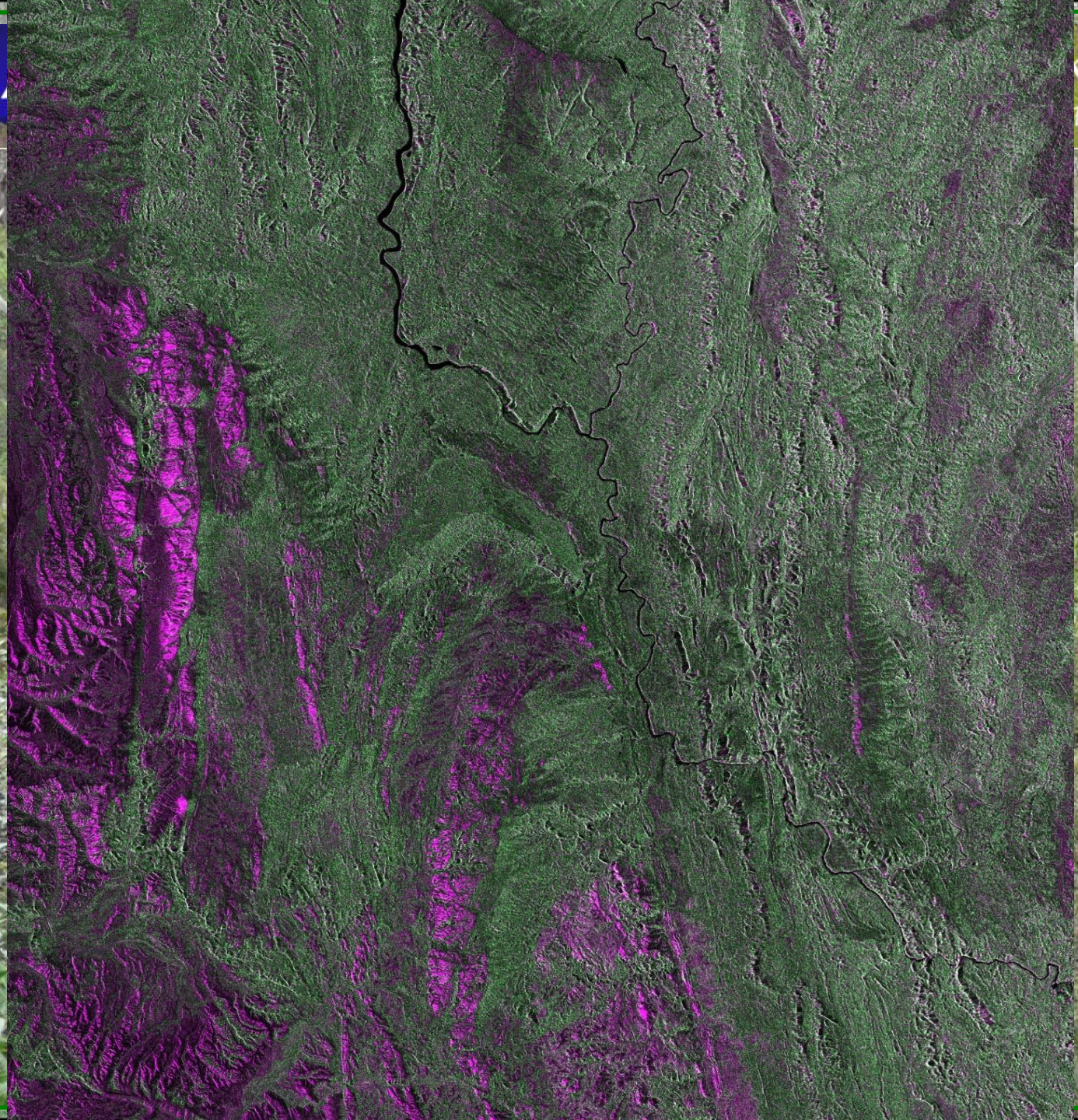
Optical-only



Combined



TASVEG



Site 2

ALOS-2 PALSAR-2 HH:HV:HH in RGB

Sentinel-1A VV:VH:VV in RGB

Landsat-8 NIR:Red:Blue

SVM classification of Land cover (6)

Forest/Non-forest

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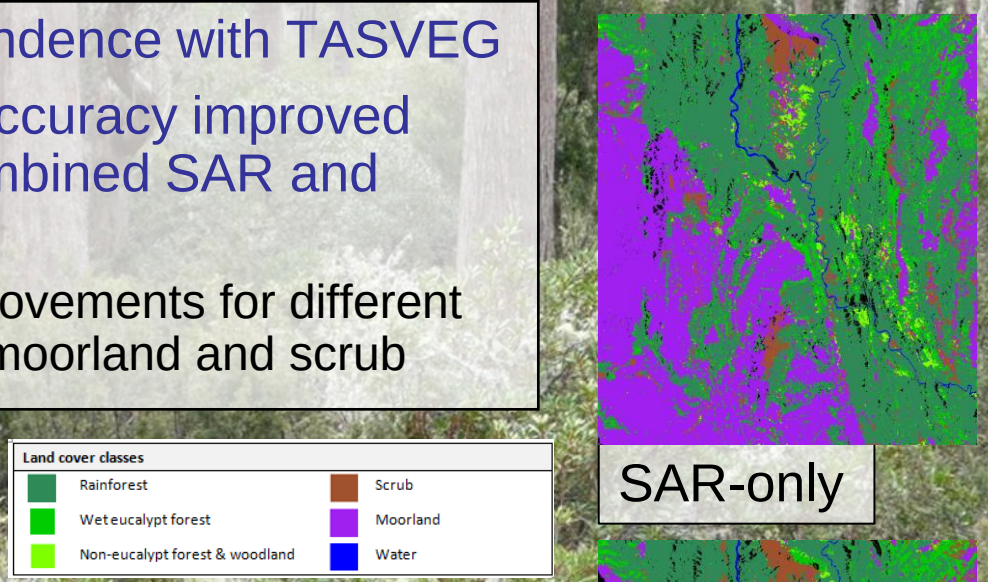
Land cover and F/NF: Site 2

- Good correspondence with TASVEG
- Classification accuracy improved when using combined SAR and Optical model
  - Mapping improvements for different forest types, moorland and scrub

SVM - Input dataset	Accuracy (%)
Land cover	
All input layers	79.6
SAR only	67.4
Optical only	79.0
Forest/Non-forest	
All input layers	91.1
SAR only	87.0
Optical only	90.4



Forest cover change: Site 3

- Identification of persistent forest and non-forest, regrowth and clearing
- Sentinel-1 time-series
  - 9 images 6/1 – 21/10 (2015)
- 3 approaches:
  - Multi-temporal object-based classification
    - Training identified for change areas and persistent F/NF
  - Change detection – mean VH difference between image pairs
    - Map of accumulated regrowth
  - Intensity and texture feature difference

6/1:30/5:21/10 in RGB

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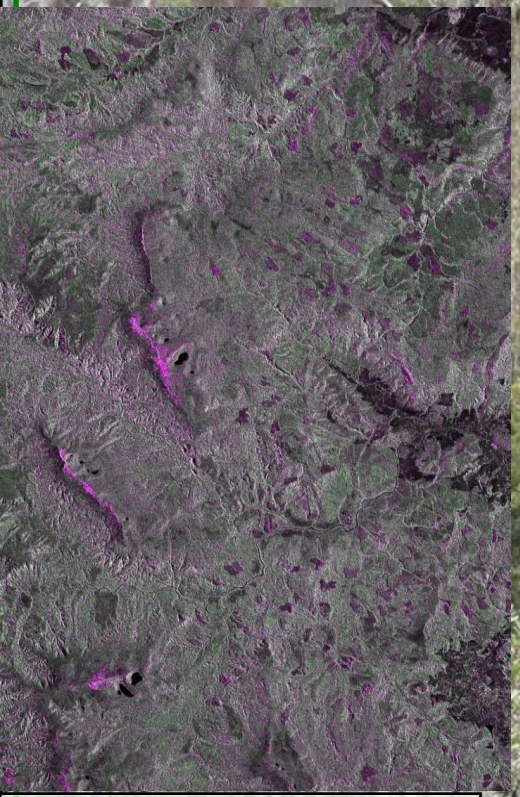
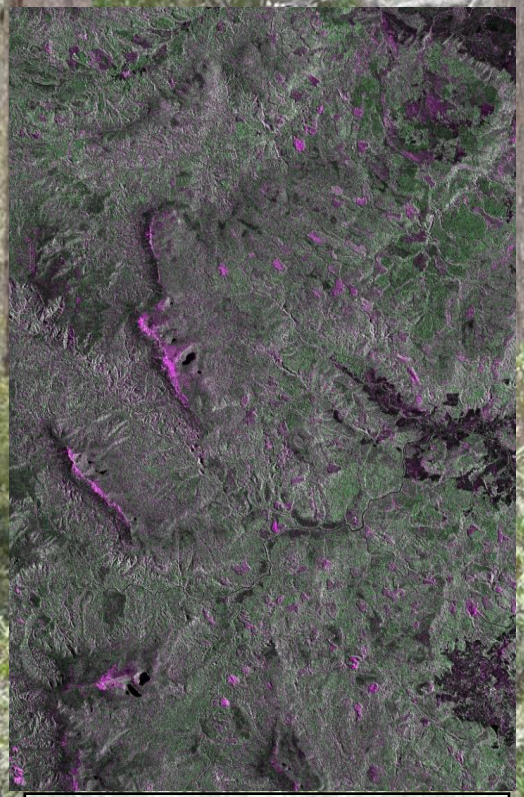
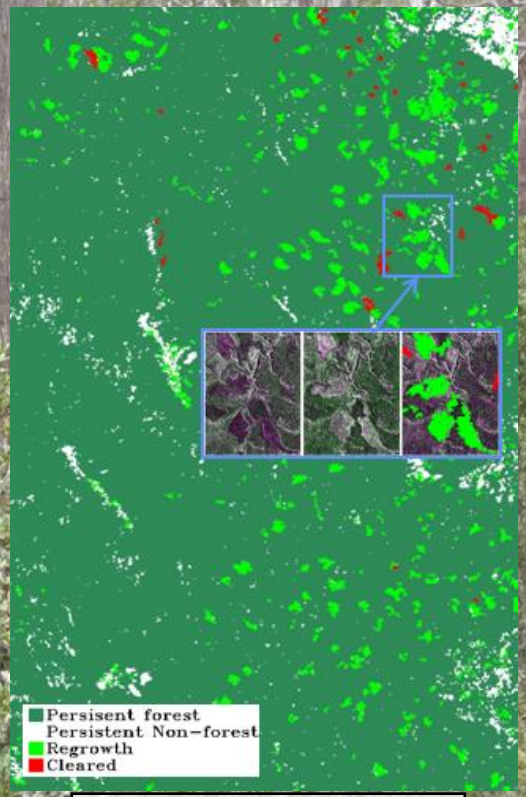


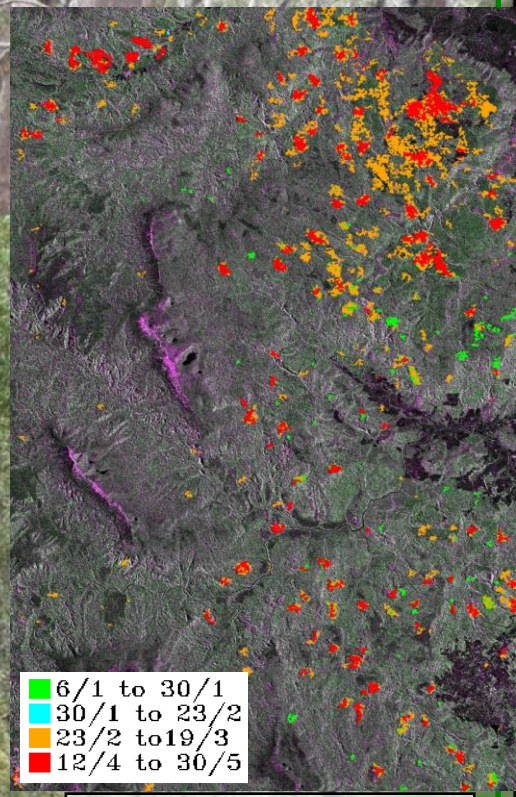
6/1/2015
VV:VH:VV in RGB



21/10/2015
VV:VH:VV in RGB



Forest cover change



Accumulated regrowth

Good correspondence with location and total area of regrowth polygons

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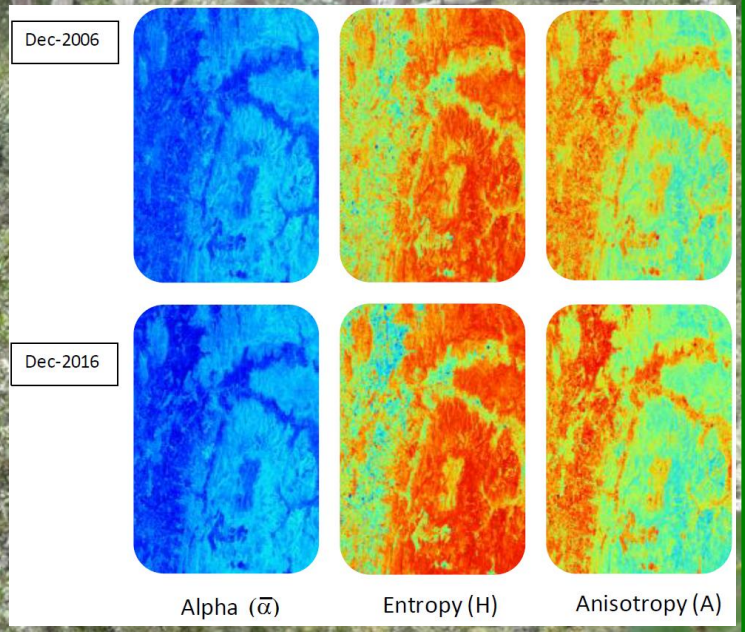
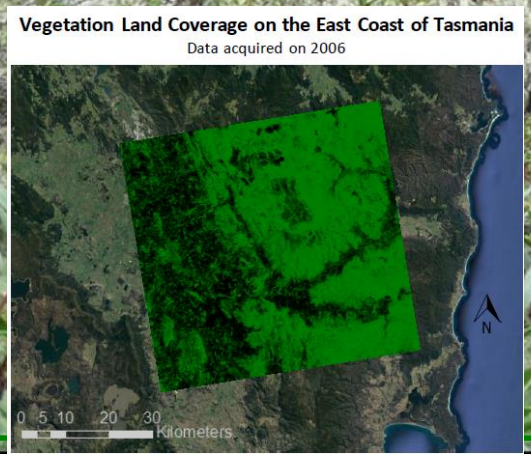
Classification of Polarimetric SAR Images using, Entropy, Alpha and Anisotropy of Cloude Decomposition

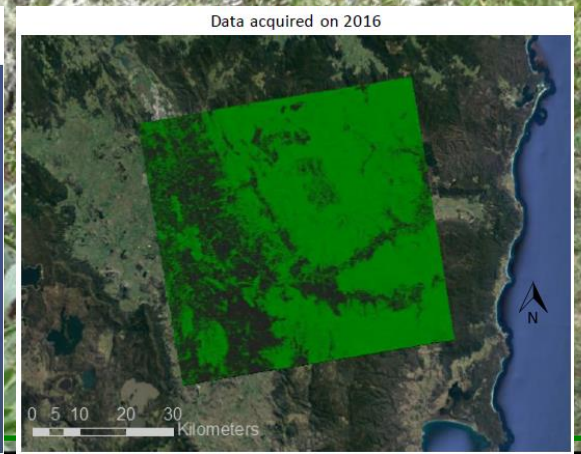
Postgraduate Research Training: Ari Villafuerte-Pereyra

- ALOS-2 Dual Pol: 16/12/2006 and 7/12/2016
- Decomposition results suggest increase in veg cover since 2006
  - Higher volumetric scattering
  - Scattering from urban areas more visible in 2016
- Supervised polarimetric classification with 2 thematic classes to observe areas with presence and absence of vegetation



Cloude decomposition





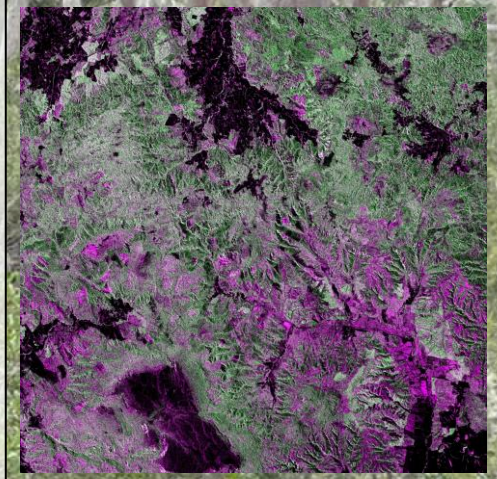
Wishart classification: 2006 (left), 2016 (right)
Vegetation (green), no veg (black)

Pol-InSAR analysis near Takone

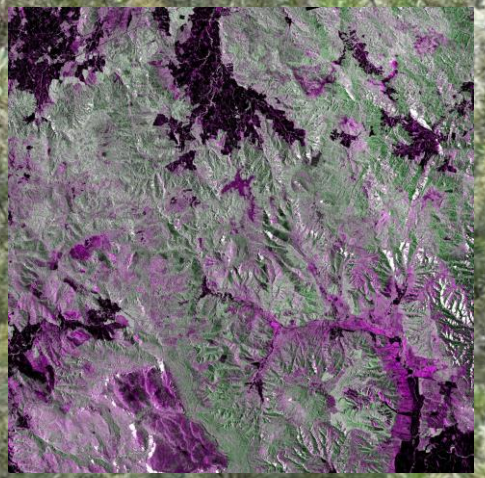
- ALOS-2 PALSAR dual pol data, HH/HV
- 8 scenes acquired between 5 Oct 2014 – 11 Dec 2016
- 3 pairs with the shortest temporal baseline of 70 days were tested
  - 26/07/2015 – 4/10/2015, Bperp = 119m
  - 4/10/2015 – 13/12/2015, Bperp = 56m
  - 13/12/2015 – 21/02/2016, Bperp = 257m
- Two layer combined surface and random volume scattering, or Random Volume over Ground (RVoG) model is applied
- Work in progress!

Tracking regrowth

- Baseline classification of forest and plantation
  - Multi-date segmentation of ALOS-1/2
    - Export object means (2010 and 2015)
  - Identify ROIs over plantation and forest
    - Refer to TASVEG (forest) and plantations
    - Extract histograms, mean and SD
  - Maximum likelihood classification
  - Validation
- Identify mature regrowth in 2015
  - Mask 2015 HV using regrowth mapped for 2010
  - Establish reference distribution for forest in 2015 HV
    - ROI mean -13.37, SD 2.48
  - Mature regrowth is 1 SD away from mean of forest
    - Apply equation to masked 2015 HV
    - Simplified approach of Lucas *et al.* 2014



ALOS1
2010



ALOS2
2015

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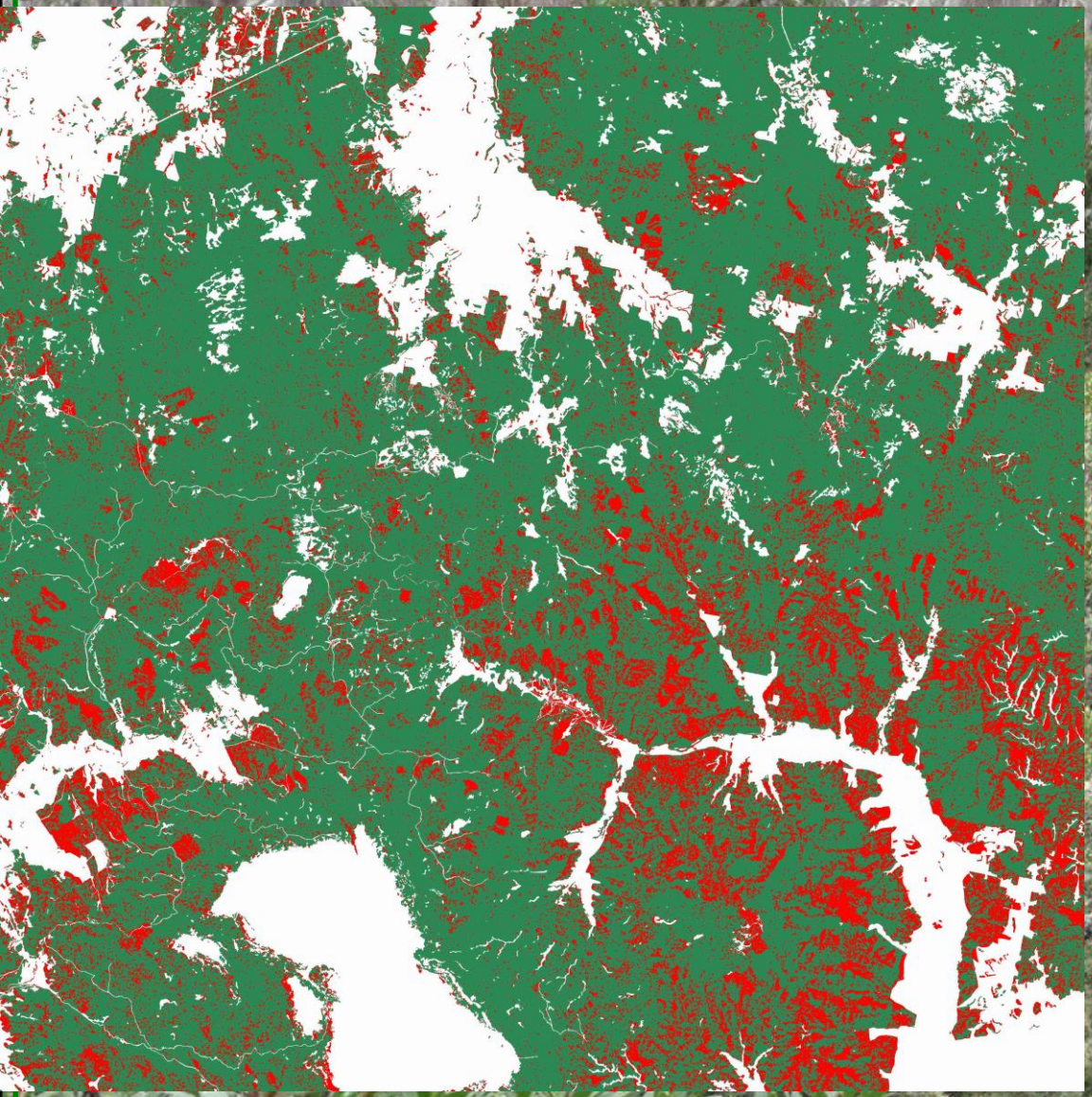


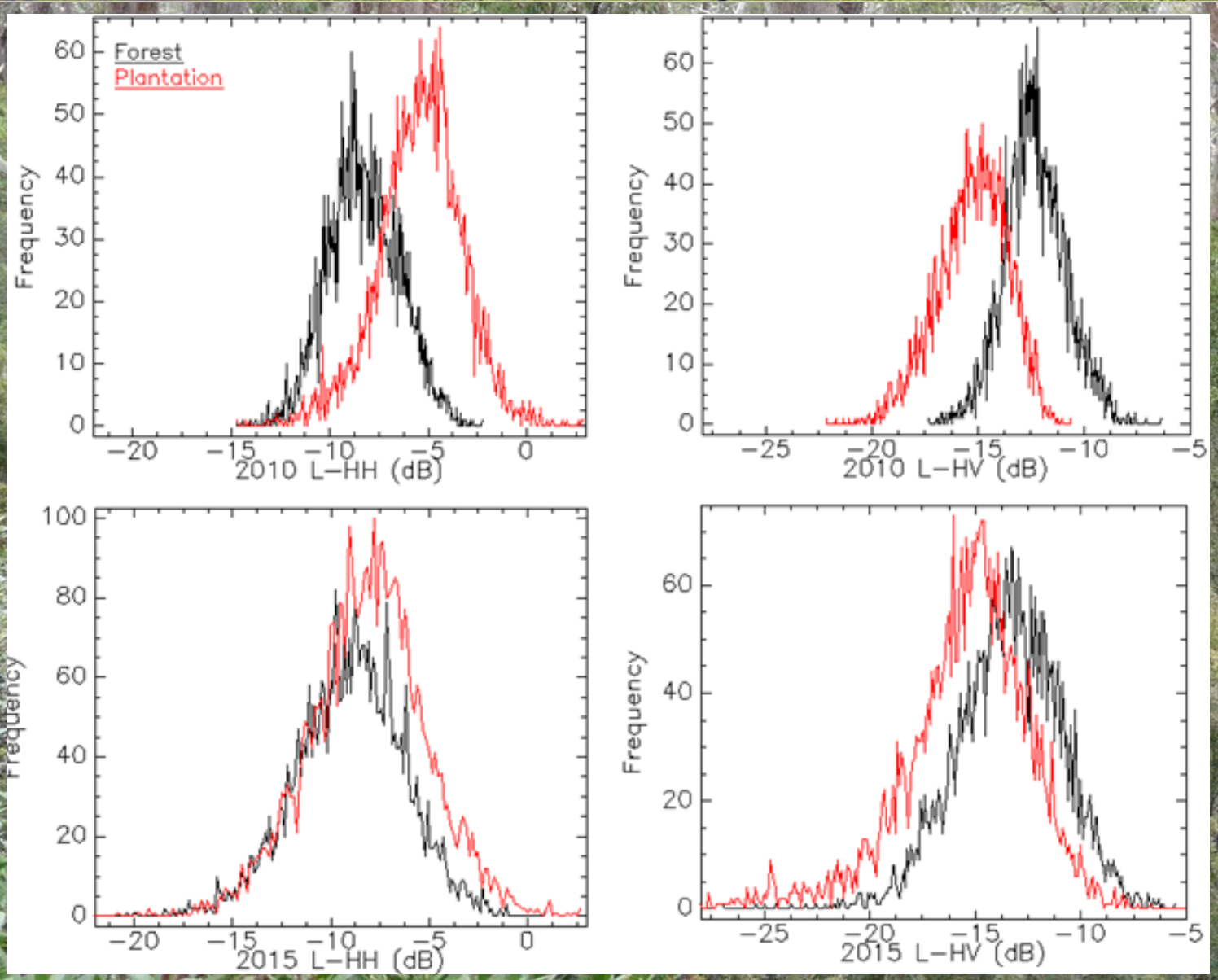
Maximum likelihood classification of ALOS-1 2010

Overall acc.: 87.8 %

Kappa coeff.: 0.69

Class	Ground truth		Total
	Regrowth	Forest	
Regrowth	92	38	130
Forest	15	291	306
Total	107	329	436

Class	Comm. (%)	Omis. (%)
Regrowth	29.3	14.0
Forest	4.9	11.6
	Prod Acc. (%)	**User Acc. (%)**
Regrowth	86.0	70.8
Forest	88.5	95.1



Frequency histograms for forest and plantation

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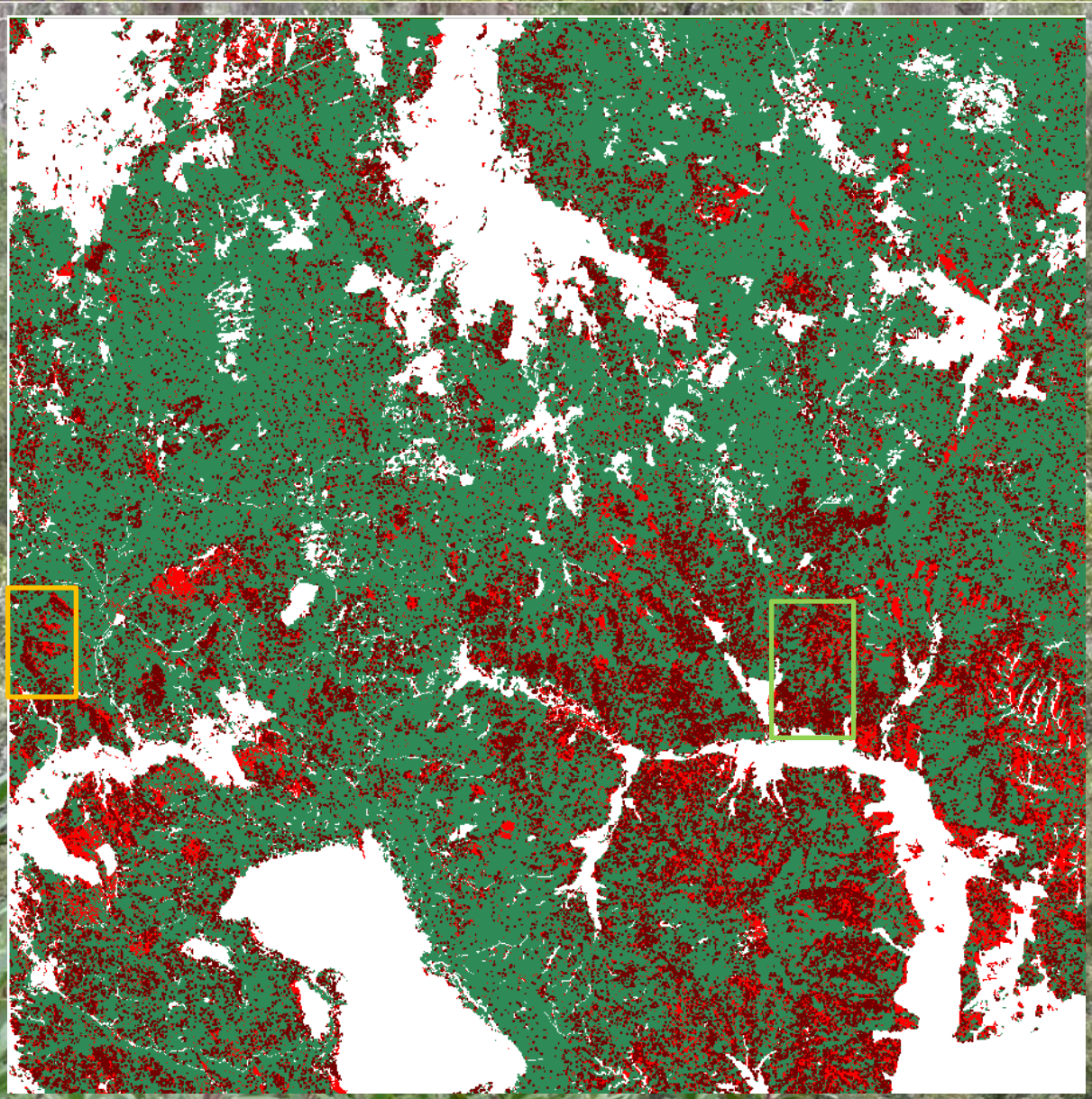
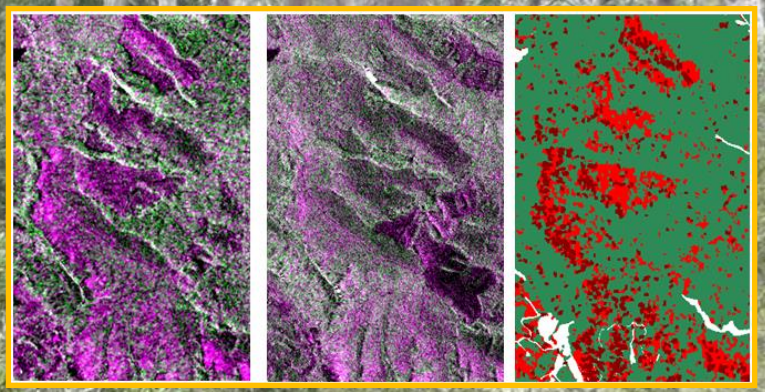
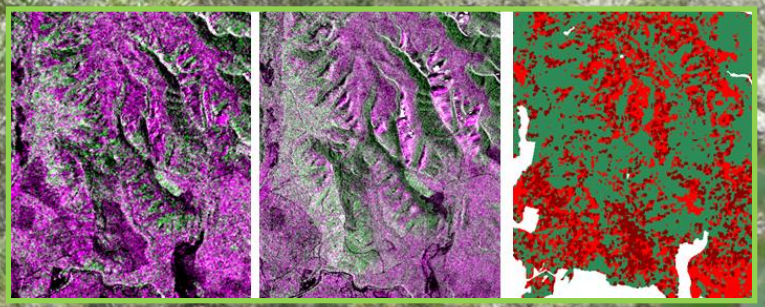


Regrowth 2010-2015 classification





2010, 2015, Regrowth

Forest
Plantation
Mature plantation
Non-forest

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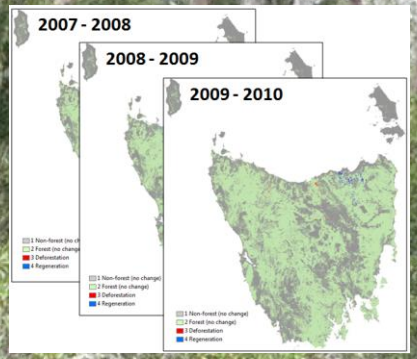
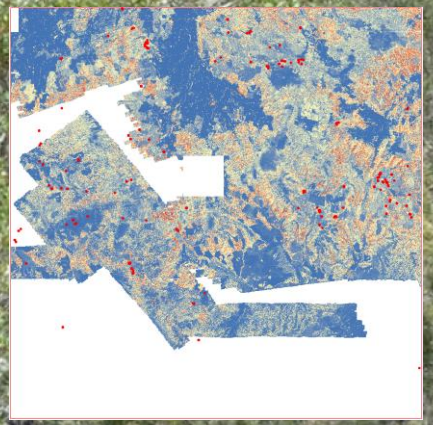
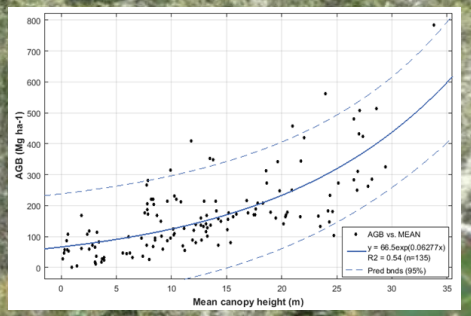
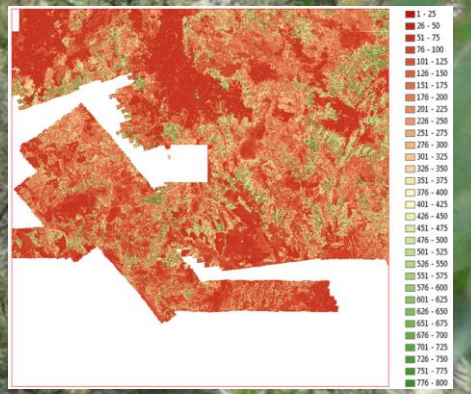
Project milestones

- Project milestones until March 2018
  - Forest cover & change
    - ALOS-1/2 FBD
    - PolInSAR
  - Improve regrowth methods
  - AGB estimates
    - Correlate LiDAR CHM and AGB
    - Calibrate SAR AGB model
- Project deliverables (March 2018)
  - C- and L-band mosaics
  - Forest/land cover maps
  - Forest cover change maps
  - Regrowth maps
  - AGB estimates (?)
  - Ground truth: cal/val data



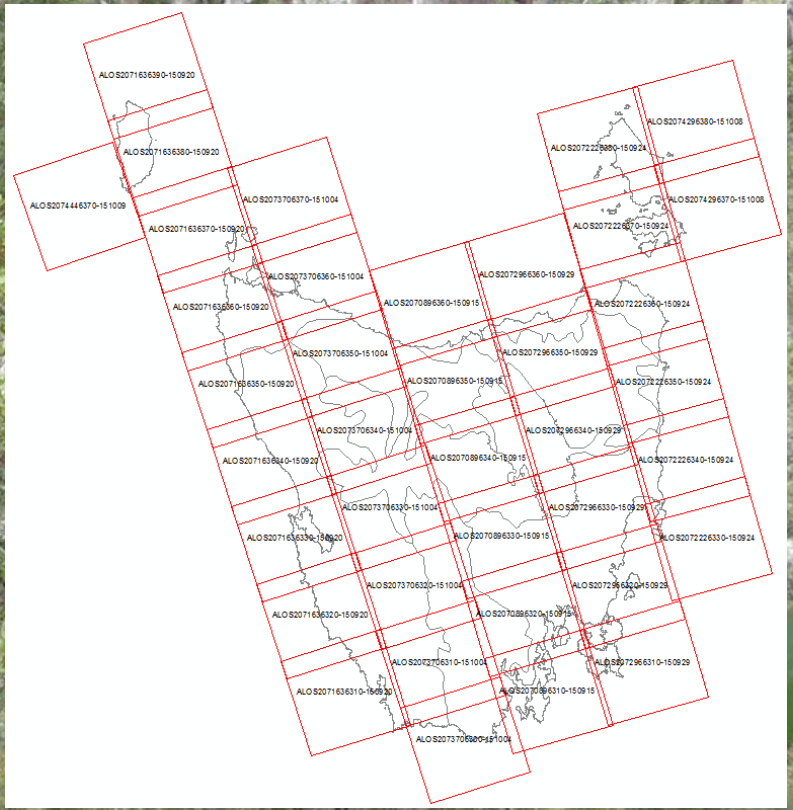






PALSAR/PALSAR-2 data access

- ALOS-2 PALSAR requested/obtained:
  - 37 FBD images acquired in 2015: OK
    - September-October 2015
    - SM3, Asc., R look
    - SLC L1.1
  - 38 FBD images acquired in 2016: 23 OK, 15 not extractable
  - 8 additional images for PolInSAR
    - Sept 2014 – Dec 2016



ALOS-2 PALSAR
2015 FBD coverage

Acknowledgements

- JAXA Kyoto & Carbon Initiative
- ESA
- USGS
- Forestry Tasmania
- DPIPWE, Tasmania