

K&C Phase 3 – Brief project essentials

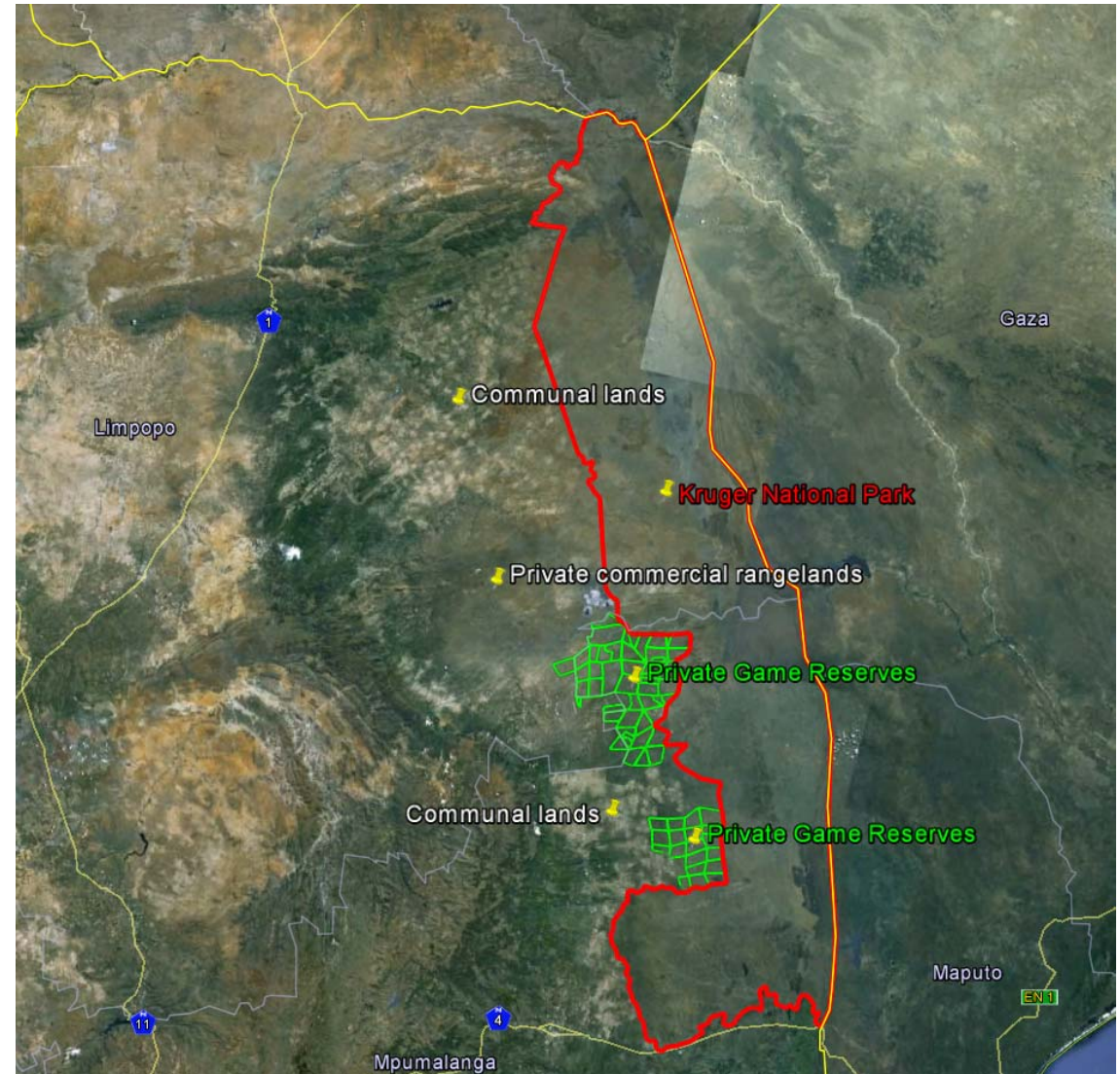
Assessing woody structural properties of semi-arid African savannahs from multi-temporal L-band ALOS PaISAR data

Renaud Mathieu, Laven Naidoo, Konrad Wessels, Greg
Asner

Council for Scientific and Industrial Research, South Africa
Carnegie Institute for Science, USA

Project area: Greater Kruger National Park, South Africa

- Woodlands and savannahs
- Ca. 60000 km²
- 10-50% woody cover
- < 60 woody T/ha biomass
- Dominant land uses: private & public conservation areas, private rangelands (beef production), communal rangelands (subsistence use)
- Issues: biodiversity conservation, energy security (fuel wood and woodland thinning), bush encroachment



Project objectives and schedule

- Primary objective: assess and develop methods to predict woody cover and biomass in southern African woodlands and savannahs using L-band ALOS PalSAR data
- Secondary objectives:
 - Investigate full polarimetric ALOS PalSAR imagery and polarimetric decompositions to improve on woody cover and biomass predictions
 - Investigate the potential of combining multiple SAR frequencies (L-band ALOS PalSAR, C-band Radarsat-2, X-band TerraSAR-X) to improve on predictions
 - Change detection of woody cover for complete Kruger National Park using ALOS PalSAR (2008-2010) and JERS-1 / Landsat (2000)

Project objectives and schedule (cont)

- Support of *the K&C thematic drivers* (**C**arbon cycle science, International **C**onventions, Environmental **C**onservation)
 - Develop methods or parameterized algorithms suitable to African open forests for prediction of woody cover and biomass
 - Assess and reduce uncertainties
 - Above ground biomass & carbon assessment (REDD+, MRV)
 - Monitoring forest (changes): land clearing, degradation, bush encroachment
 - UNFCCC, Kyoto Protocol

Project objectives and schedule (cont)

- List the project milestones
 - Milestone 1 (11/2012): field & airborne LiDAR campaign
 - Milestone 2 (12/2012): LiDAR data processing
 - Milestone 3 (04/2013): SAR data acquisition, and SAR processing chains (including training and script development, i.e GAMMA)
 - Milestone 4 (09/2013): Assessment of multifrequency SAR for woody and biomass prediction
 - Milestone 5 (12/2013): Assessment of dual and full polarimetric ALOS PaSAR for woody and biomass prediction
 - Milestone 6 (02/2004): 2000 – 2010 change analysis over Kruger National Park

Support to JAXA's global forest mapping effort

- Support to JAXA's global forest mapping effort
 - Develop methods or parameterized algorithms suitable to mapping African open forests
 - Local / regional maps can be used for validation of global maps
- List ground truth data that will be shared with JAXA
 - Georeferenced estimates of tree cover (classes with 20% increment)
 - Data extracted from field work and classification of very high resolution satellite imagery
 - Locations: woodlands and savannahs (Limpopo and Mpumalanga provinces); coastal forests and plantations (KwaZulu-Natal province)

Deliverables

- Planned outputs of the project:
 - Woody cover and biomass maps in the South African Lowveld
 - Woody cover change maps for the Kruger National Park
 - Woody cover ground truth plots
 - Final report: Mapping woody cover and biomass in South African savannahs and woodlands using ALOS Palsar
 - Presentation: K&C meeting, 1 local conference, 1 international conference (in 2014)
 - Peer-reviewed publication: 1 (in 2014)

Overall context

- Savannahs and woodlands: mixed grass and woody layer
- Worldwide, one sixth of the land surface; 3rd carbon pool after tropical and temperate forest
- Key biome in Africa and southern Africa
 - Forests covers **37.1%** in South Africa: 42 m ha (**35%**) of woodlands & savannahs, 1.2 m ha (**1.1%**) of plantations, 0.5 m ha (**0.5%**) of indigenous forests



Specificities of savannahs and woodlands in southern Africa

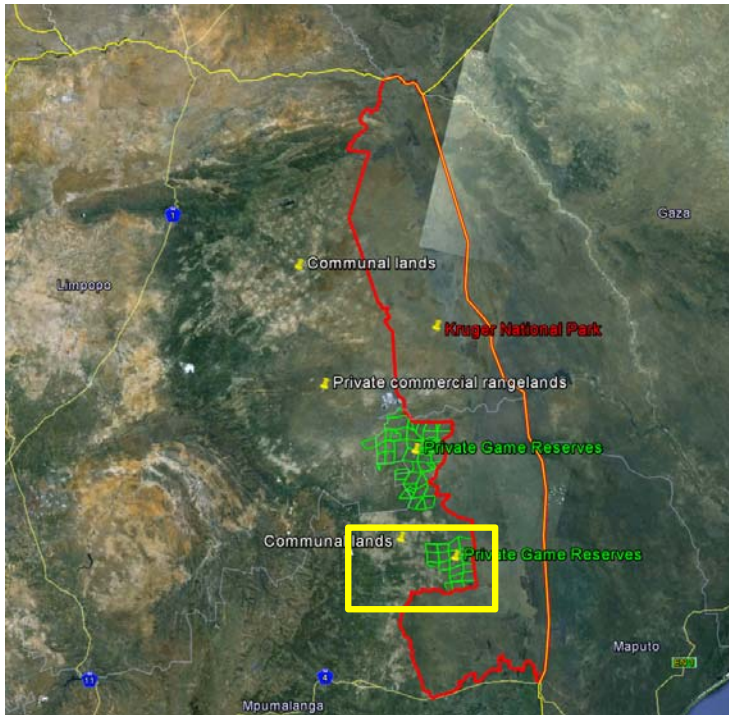
- Arid / semi-arid: low range of biomass (<60 t/ha)
- Mostly gradual changes: logging, encroachment
- Fine scale heterogeneity = remote sensing challenge
 - Woody plant size & cover (3-6 m, 10-40%)
 - Soil properties & water availability
 - Disturbance factors: fire, herbivore, human
- Woody plant: multi-stemmed clumps, high biomass in branches rather than in main stem
- Importance in local and regional context:
 - Food (open woodland for cattle grazing) / energy security (fuel wood) → poor communities
 - Climate change / carbon accounting (REDD+)
 - Climate modeling / vegetation dynamic (grass vs. woody)



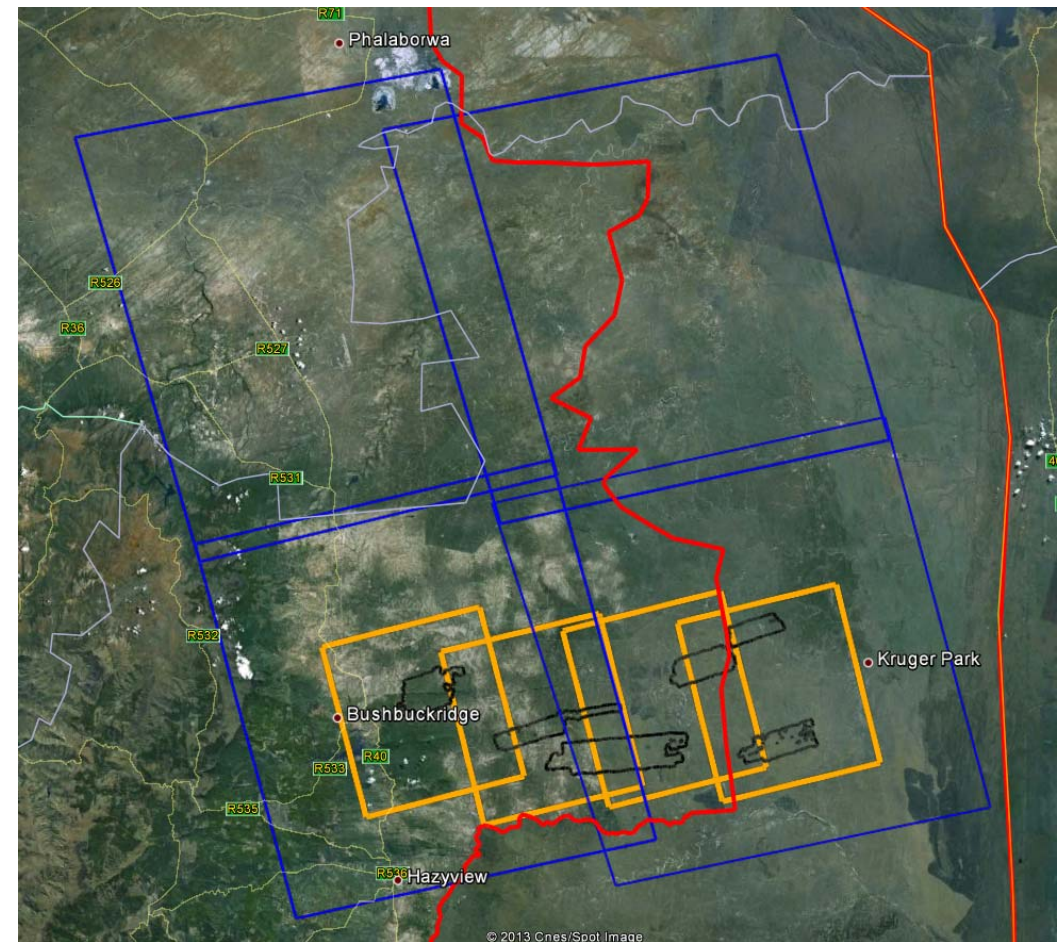
Objective: initial results

- Objective: Assess the relative performance of L-band, C-band, and combined L-band / C-band for prediction woody cover in semi-arid savannahs in South Africa
- Hypothesis: Combination of L-band and C-band will provide the best performance, because of the capacity of L-band to detect large woody features and C-band small woody features; this mix being prevalent in these environments where big trees mixed with dense shrub cover

Study area / dataset



Focus on selected land use transect (yellow, conservation, communal rangelands) for methodological research as a large dataset is available (Radarsat, TerraSAR, PALSAR); PalSAR to be used to upscale over the whole Kruger park and surroundings

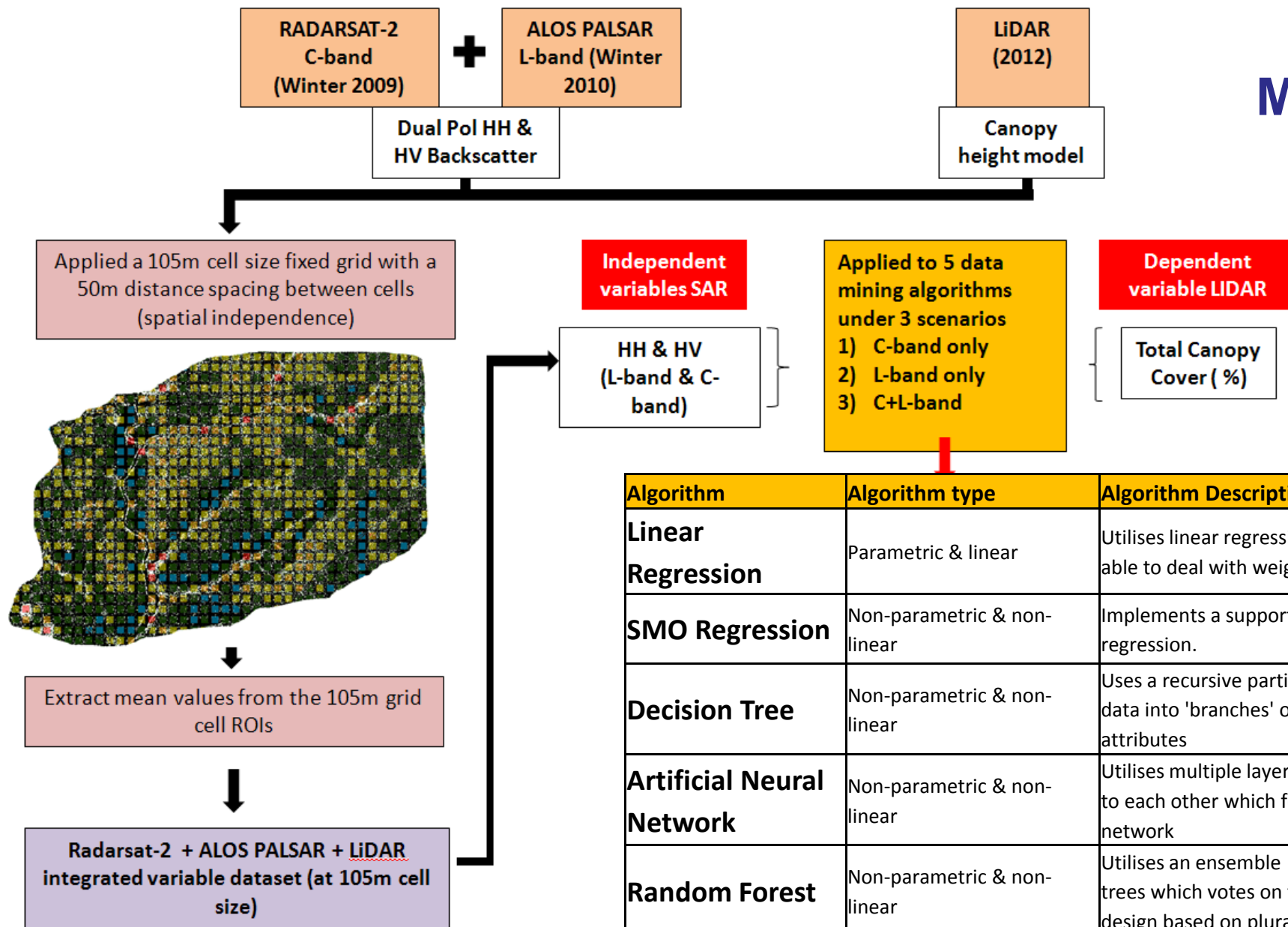


Blue = PALSAR tracks, Orange = Radarsat tracks, Black = LiDAR tracks

Study area / dataset

Image ID	Sensor	Mode	Spatial Resolution	Incidence angle	Acquisition time	Season
FQ15 FQ20 FQ13 FQ18	RADARSAT-2 C-band	Quad Polarized (HH, HV, VH, VV) but HH and HV only used	5m	34.4 - 36.0° 39.3 - 40.1° 32.4 - 34.0° 37.4 - 38.9°	13/08/2009 06/08/2009 06/09/2009 30/08/2009	Winter 2009
ALPSRP242696680 ALPSRP242696690 ALPSRP245176680 ALPSRP245176690	ALOS PALSAR L- band	Dual Polarized (HH & HV)	12.5m	34.3°	14/08/2010 14/08/2010 31/08/2010 31/08/2010	Winter 2010
	CAO LiDAR	Discrete Footprint	1.1m	Nadir	1/04/2012- 24/05/2012	End summer 2012

Methods



Results

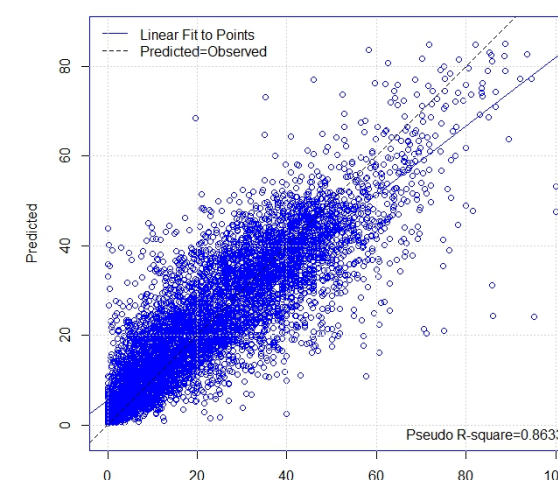
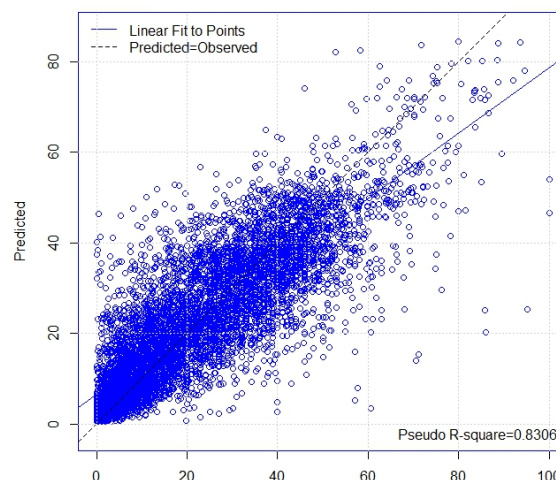
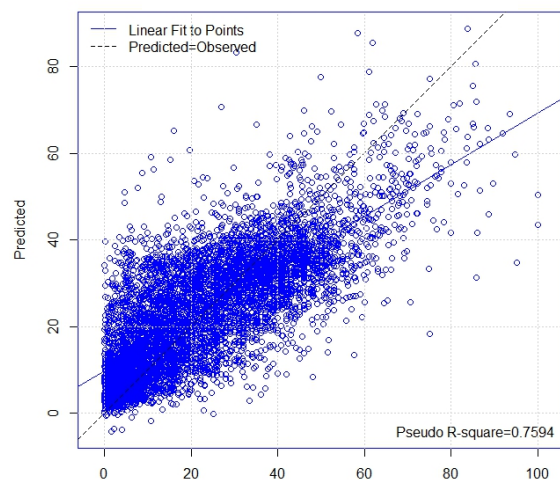
C-, L- and C+L Band TCC (%) Modelling Results [35% Training; 65% Validation]							
Algorithm	Algorithm type	C-band only		L-band only		C+L band	
		R ²	RMSE	R ²	RMSE	R ²	RMSE
Linear Regression	Parametric & linear	0.72	12.42	0.81	10.36	0.83	9.91
SMO Regression	Non-parametric & non-linear	0.72	12.61	0.82	10.61	0.83	10.05
Decision Tree	Non-parametric & non-linear	0.73	12.09	0.82	10.18	0.83	10
ANN	Non-parametric & non-linear	0.76	11.55	0.83	9.96	0.83	9.91
Random Forest	Non-parametric & non-linear	0.75	11.82	0.83	9.89	0.86	8.96

C-band ANN

L-band RF

C- & L-band RF

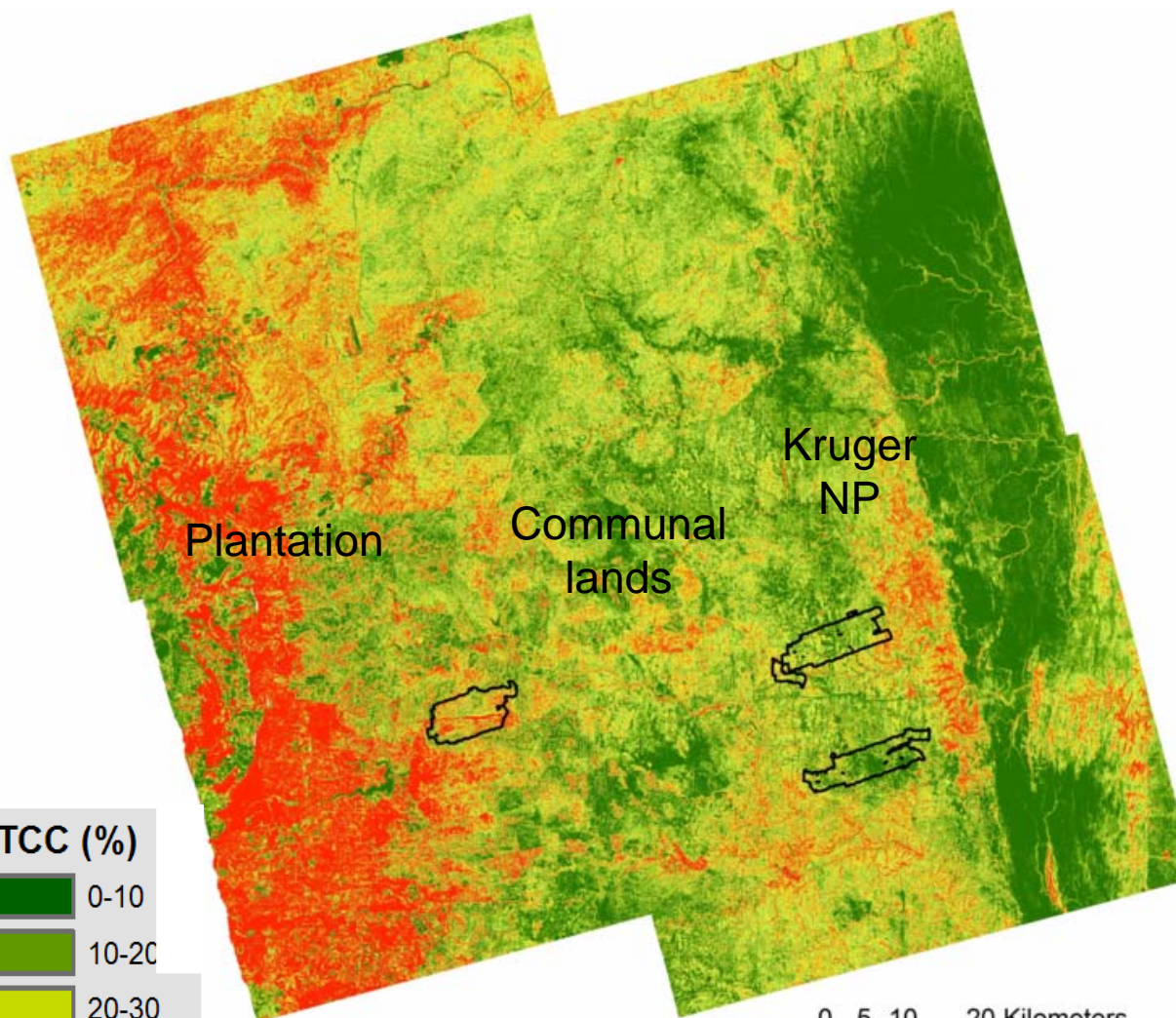
TCC
predicted



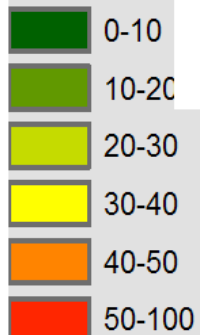
TCC observed

TCC observed

TCC observed

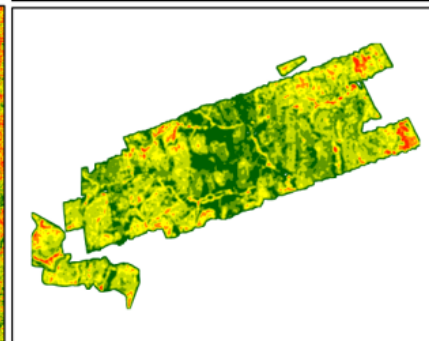
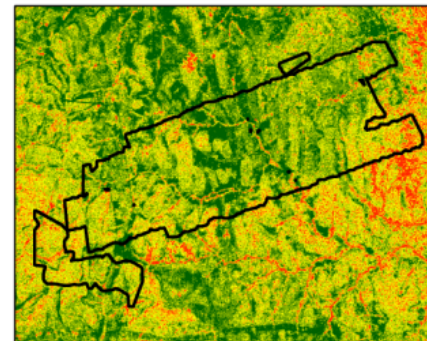
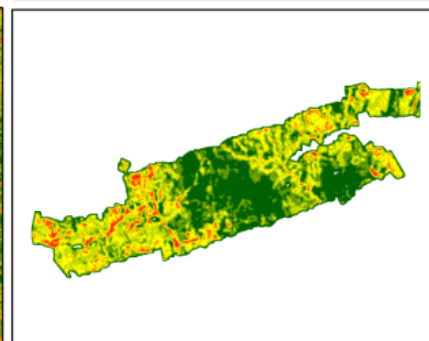
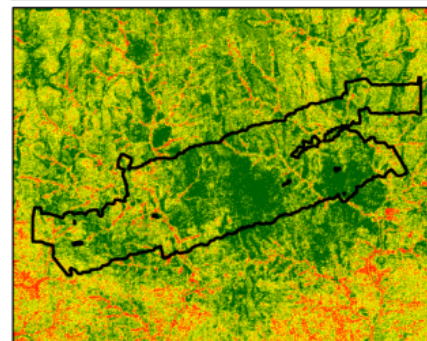
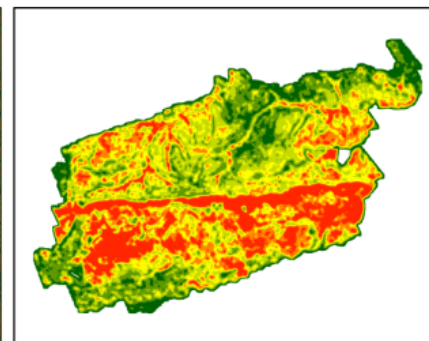
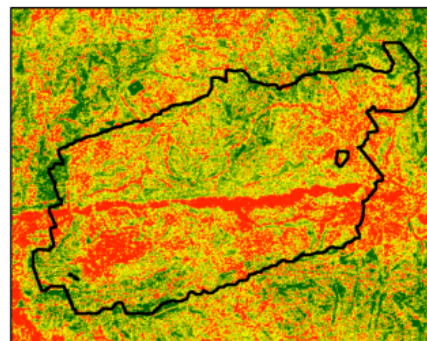


TCC (%)



L-band
prediction

LiDAR
observation



Next steps

- Integration of TerraSAR-X coverage
- Analysis of errors (spatial patterns, contribution of single SAR frequency)
- Extend 2010 L-band prediction to complete Kruger Park and change detection using earlier map produced with JERS-1 / Landsat (2000)
- Assess multi-temporal and fully polarimetric ALOS-PaISAR dataset

Thank you!

Acknowledgement:

Data: Carnegie Institute of Science, JAXA

Funding: EU FP7 AGRICAB, SA Department of Science and Technology

