WP 5000

Regional site: South Africa

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Regional site: South Africa

The South Africa regional case encompasses the eastern forest belt of the country including:

- the eastern part of the Mpumalanga province
- the Limpopo Provinces to the north-east
- KwaZulu-Natal and a large part of the Eastern Cape Province to the south.

Area: 333 500 km²

1 300 km from N to S

- Maps of AGB with uncertainties 2005- 2010- 2015
- Maps of AGB changes
- 25 m
- RMSE<30%

Remote sensing data

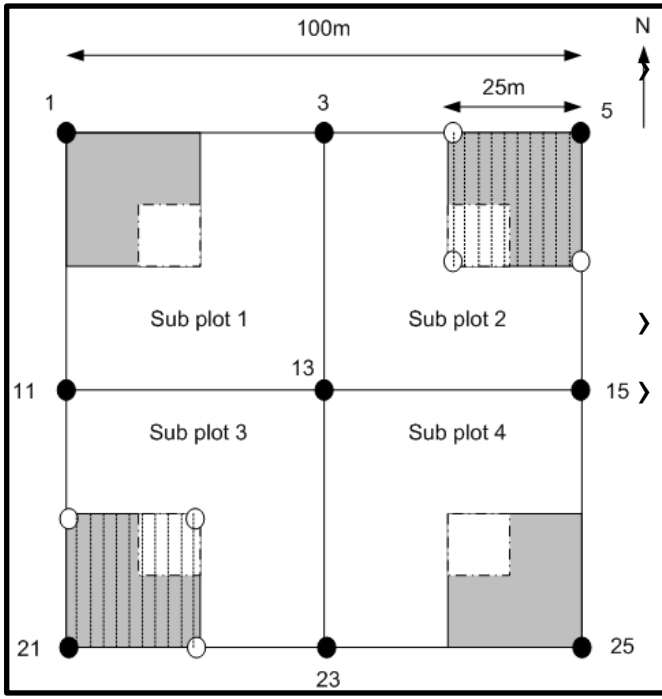
DATASET	SPATIAL RESOLUTION	2000	2005	2010	2015
ALOS PALSAR archived mosaics (HH, HV)	25 m		x	x	
ALOS2 PALSAR2 FBD and mosaics (HH, HV)	25 m				x
Landsat products	30 m	x	x		
Shuttle Radar Topography Mission-SRTM[(1)]	30 m	x			

In situ data for 2010 epoch

The in situ AGB plots data have been measured in **2012** by CSIR (scientific partner and GlobBiomass user from South Africa)

37 1-ha plots in KNP savanna (0-60T/ha, 0-70% tree cover)

The plots will be used for calibration and validation.



Nested sampling within plots

- All trees > 10cm DBH
- Trees between 10 and 5 cm DBH, 25% of plot area
- Trees between 5 and 3 cm DBH, 4% of plot area

Collected tree height, DBH, species

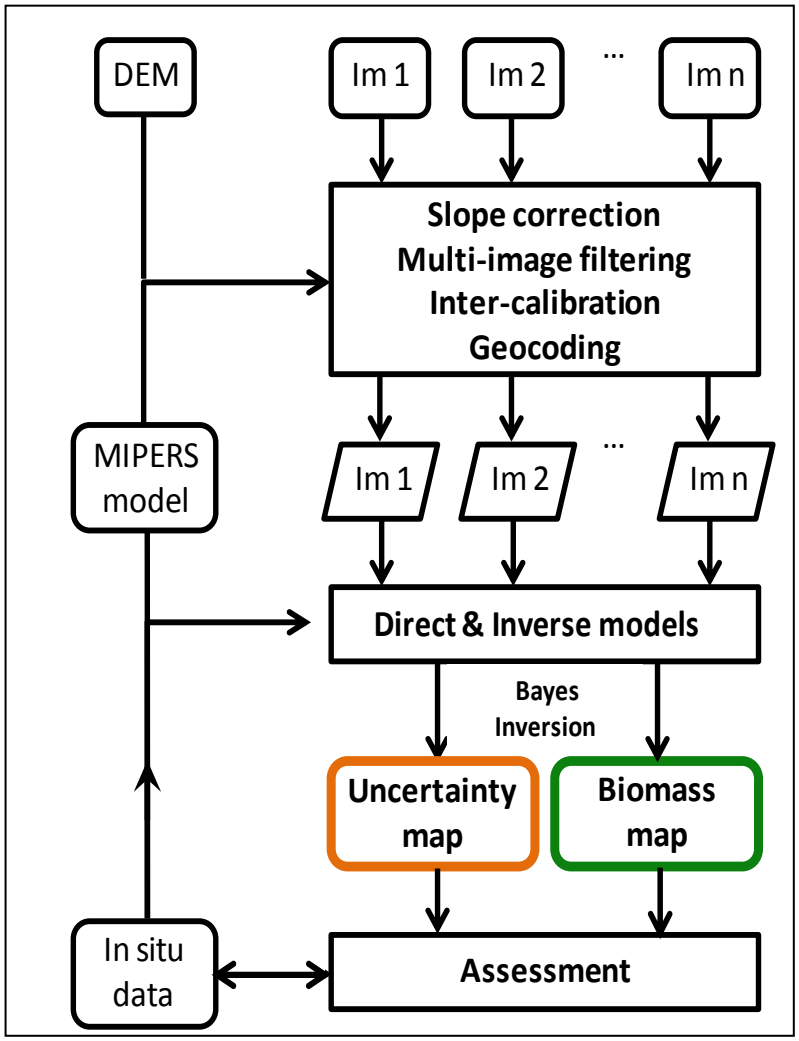
Species specific allometric equations: Colgan et al (2012)

100 x 100 m stem above 1.5 m and 10 cm dbh

25 x 25 m stem above 1.5 m and 5 cm dbh

10 x 10 m stem above 1.5 m and 3 cm dbh

Methodology used for biomass estimation



Preprocessing

- Multi-image filtering
- Inter-calibration of image

Analysis

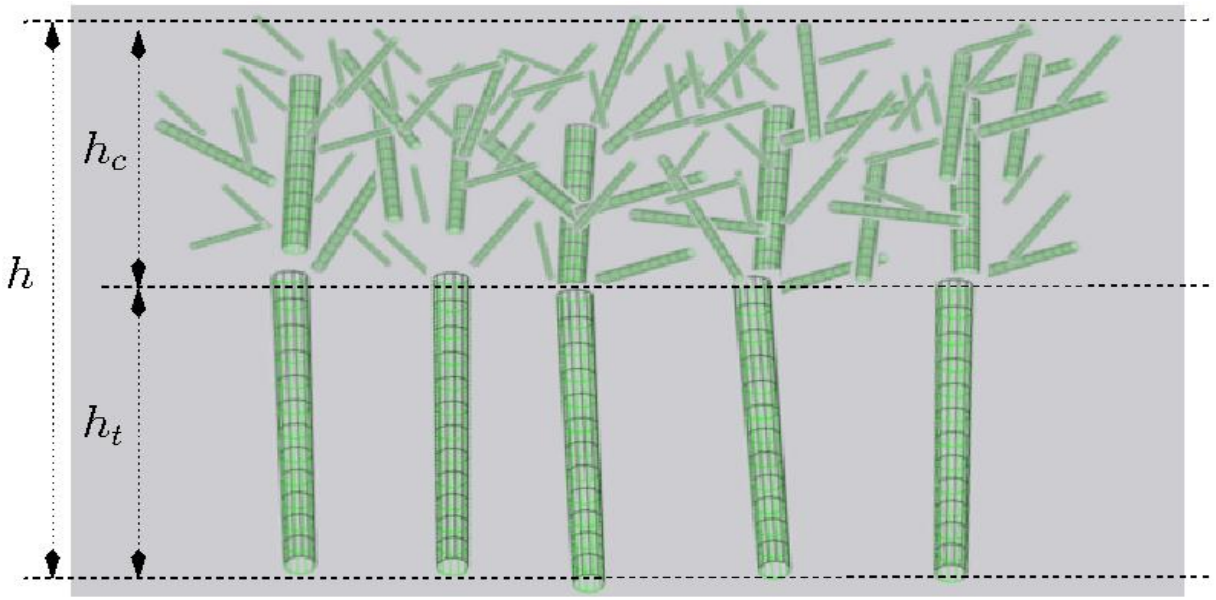
Inversion method

- Bayes approach

Uncertainty assessment

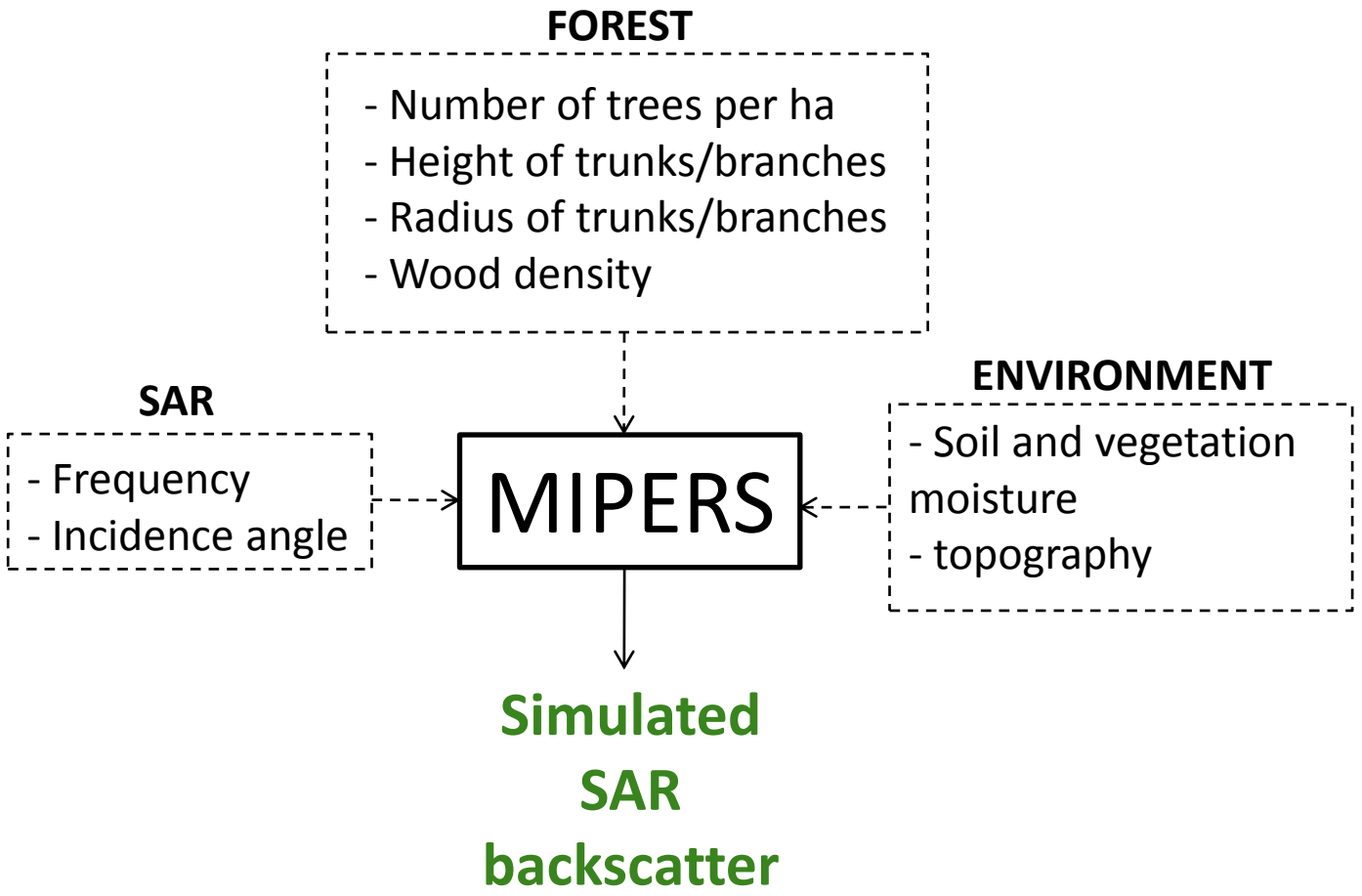
- Error budget and biomass uncertainty map

Theoretical modelling of relationships between SAR backscatter and biomass



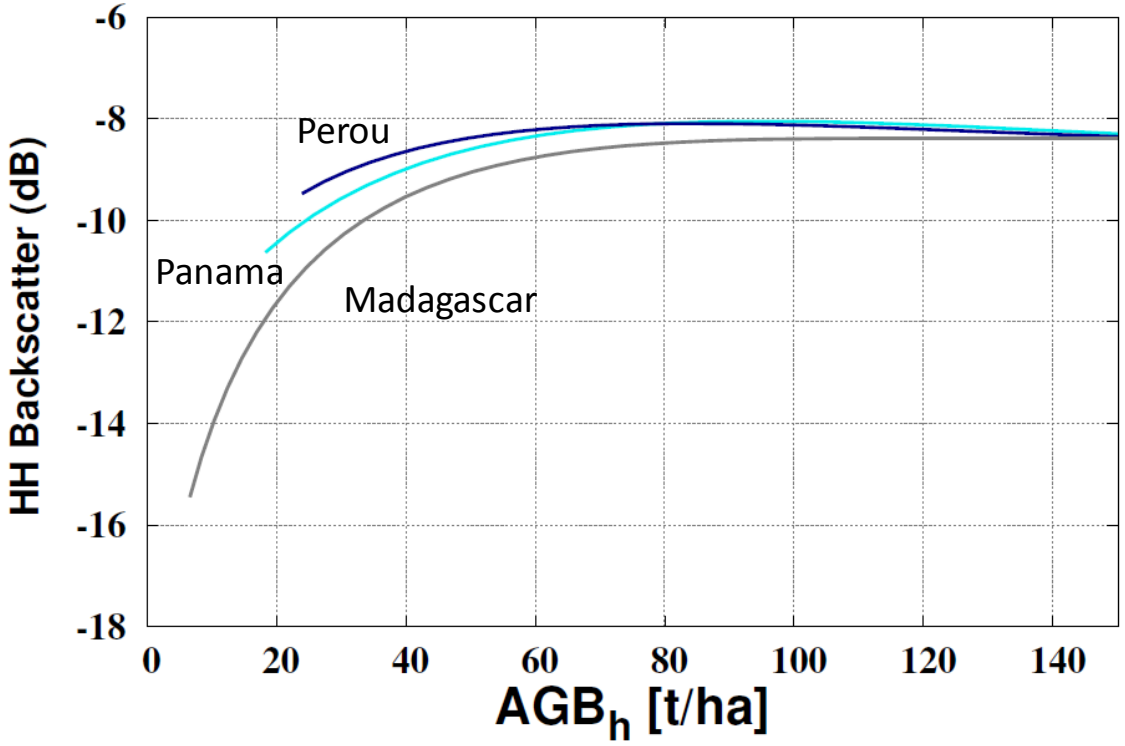
Using electromagnetic modeling (MIPERS, Villard et al. 2009) to simulate the radar backscatter from a forest canopy described as a structured ensemble of scatterers (cylinders for stem, branches, ellipsoids for leaves)

To derive the MIPERS model inputs



Simulations of perturbing effects

Simulations at L-band 35° HH (PALSAR)



Semi-empirical SAR/biomass relationships

Simplified Water Cloud Model (WCM):

$$\gamma^0 = \gamma^0_{ground}.e^{-c.AGB} + \gamma^0_{veg}.(1-e^{-c.AGB}) = ae^{-c.AGB} + b(1-e^{-c.AGB})$$

a = γ^0_{ground} = γ^0 for AGB=0 (ground)

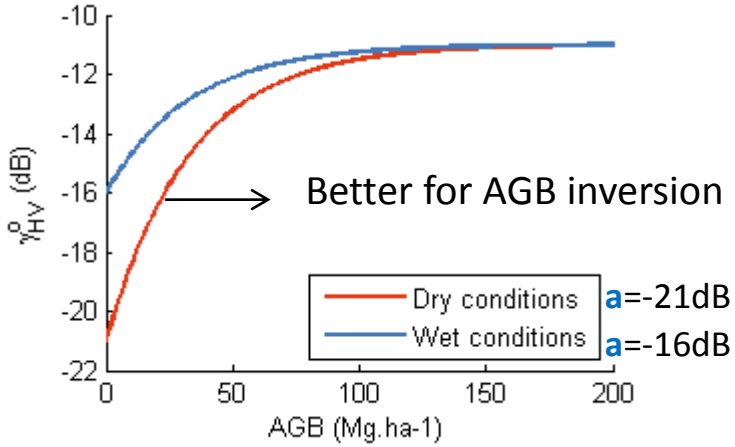
b = γ^0_{veg} = γ^0 for AGB=∞ (dense forest) / saturation level

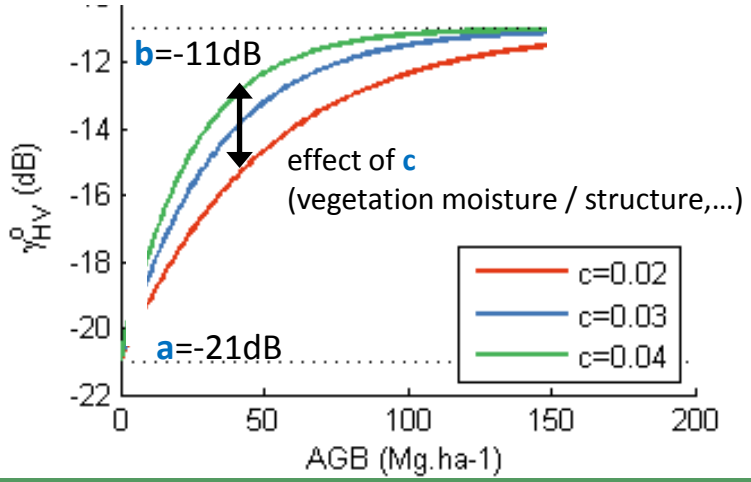
c = attenuation coefficient of the vegetation layer

= « quickness » of rise from **a** to **b**

The model can be applied to HV and HH.

a, **b** and **c** are defined by fitting the curve to field plots and/or using ancillary data.





Estimation of model parameters

Simplified Water Cloud Model (WCM):

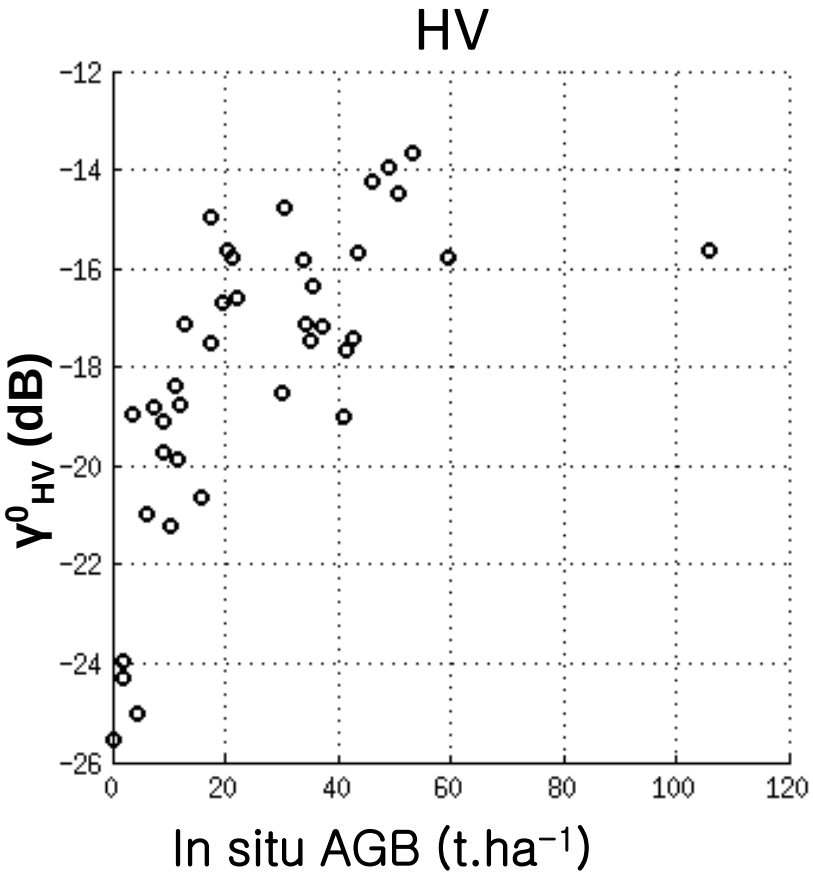
$$\gamma^0 = \gamma^0_{ground}.e^{-c.AGB} + \gamma^0_{veg}.(1-e^{-c.AGB}) = ae^{-c.AGB}+b(1-e^{-c.AGB})$$

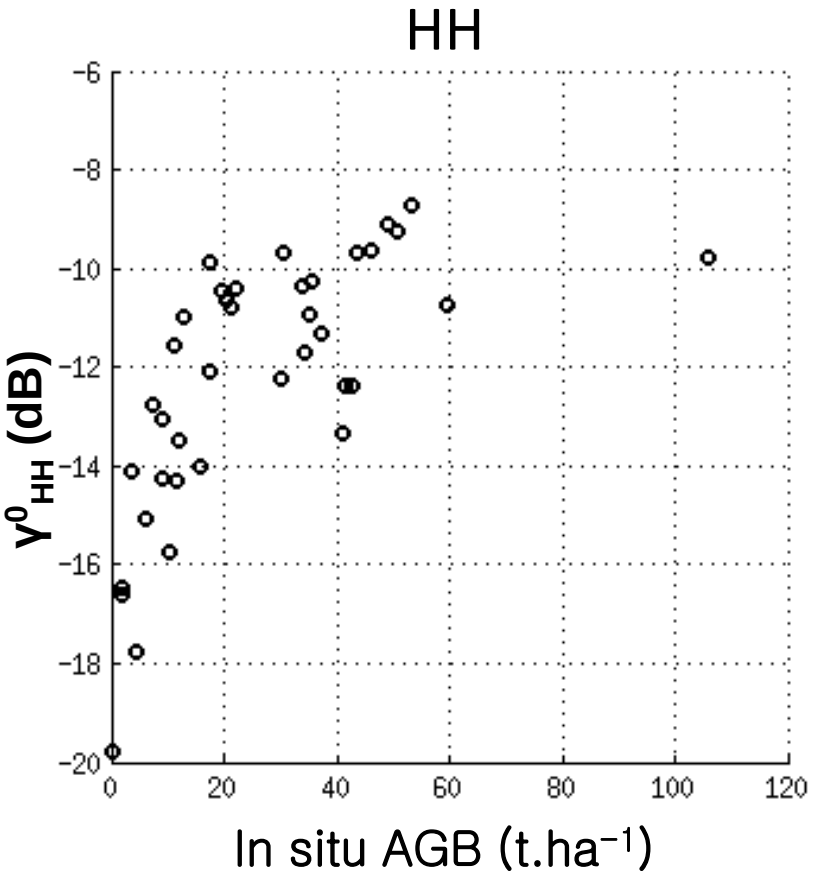
- If a large number of well-distributed above-ground measurements are available:
  - the three parameters **a**, **b** and **c** can be estimated using statistical regressions

- Alternatively:
  - **a** and/or **b** can be assessed with the help of ancillary data. For example, open areas and dense vegetation can be identified using Landsat Tree Cover data. **a** and/or **b** are then calculated from the SAR data.
  - Then, **c** is estimated through a statistical regression using the available *in situ* data.

Estimation of model parameters

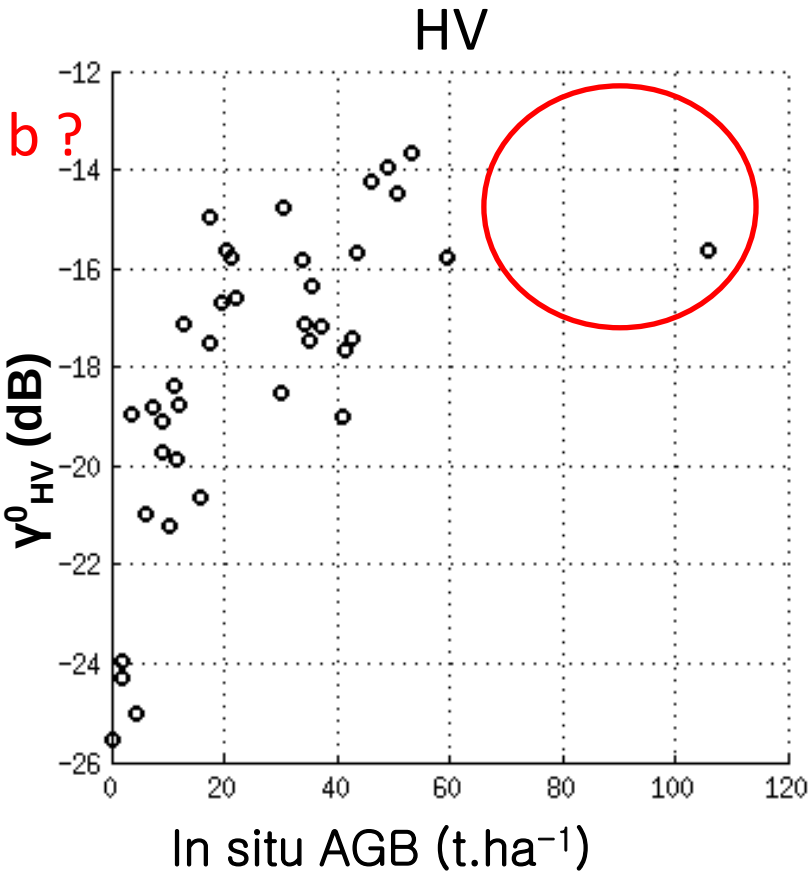
ALOS 2010

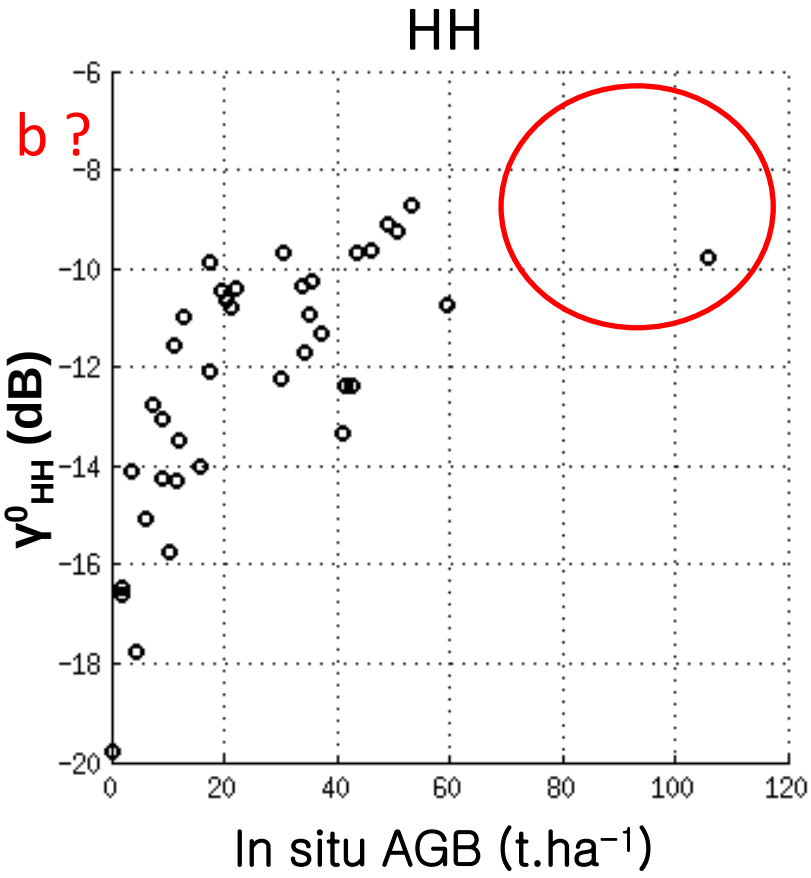




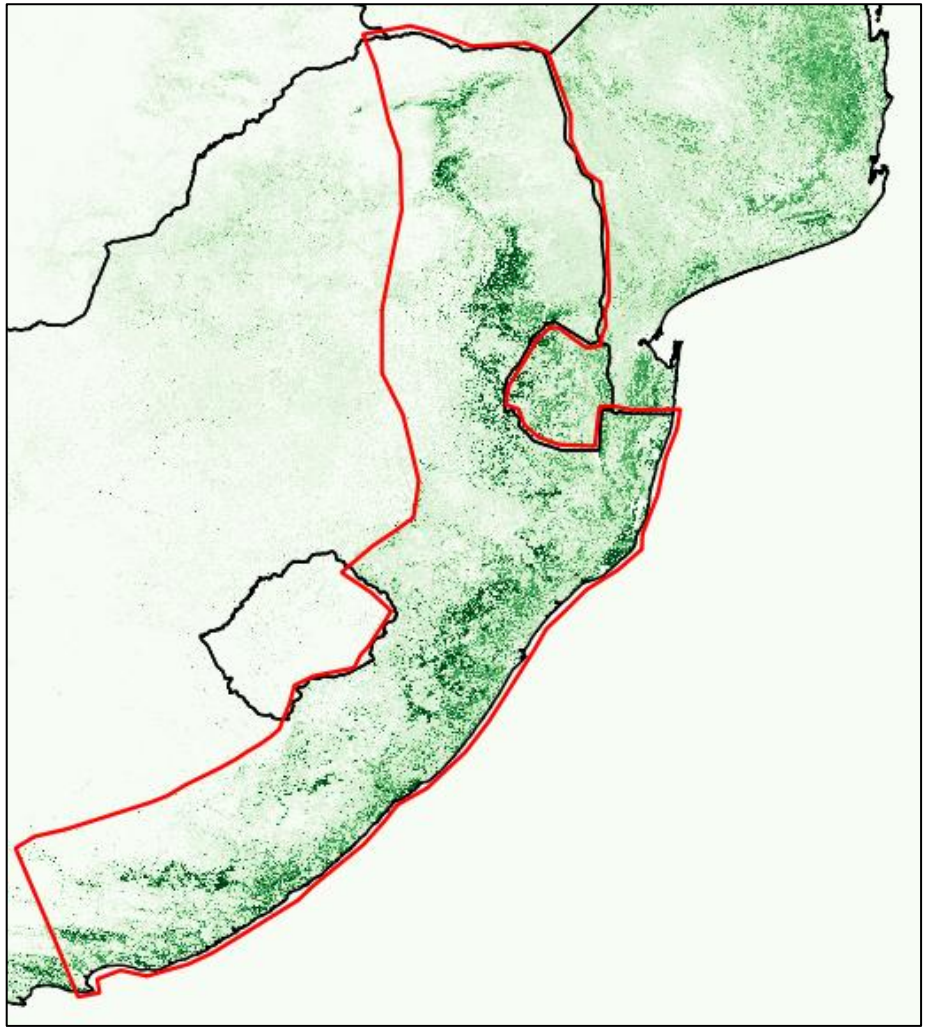
Estimation of model parameters

Problem: no data over 60 t.ha^{-1} to estimate b parameter

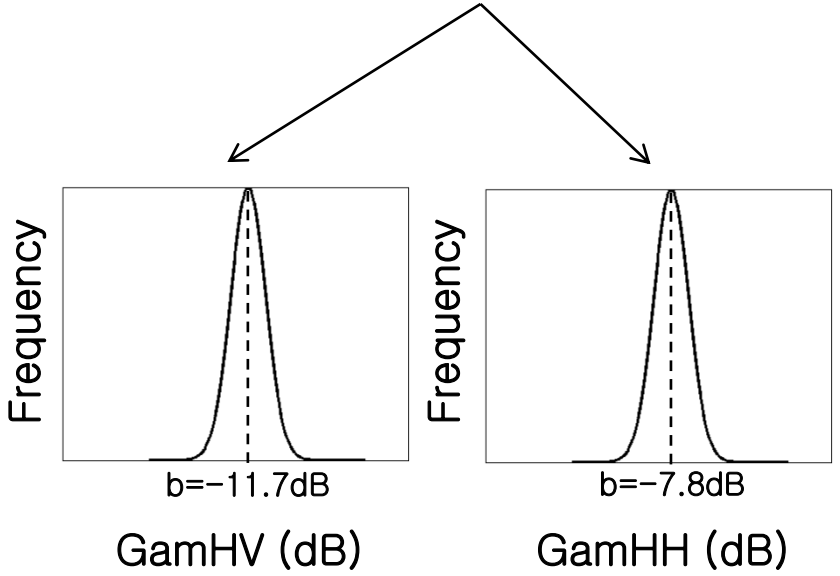




Estimation of model parameters

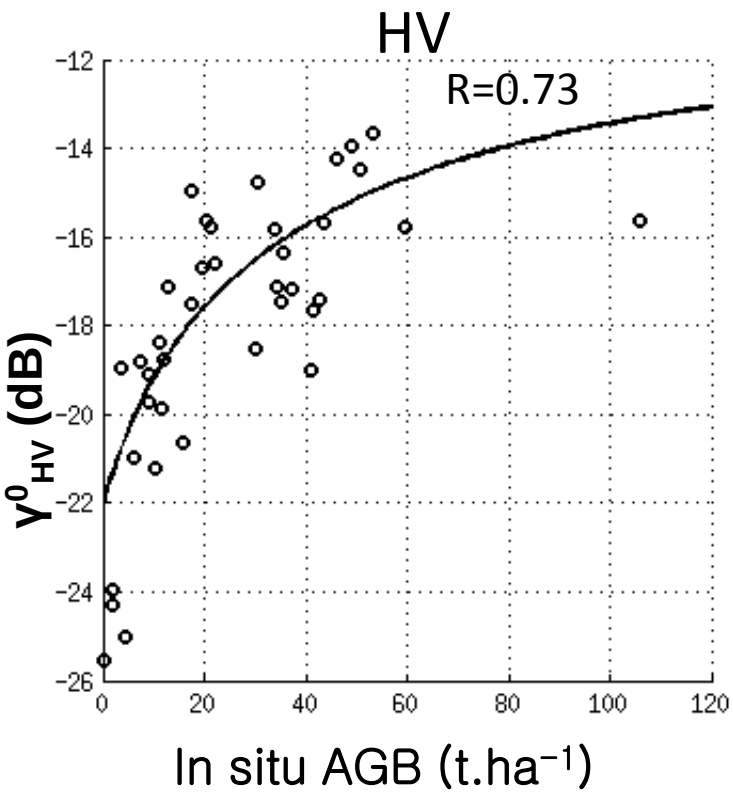


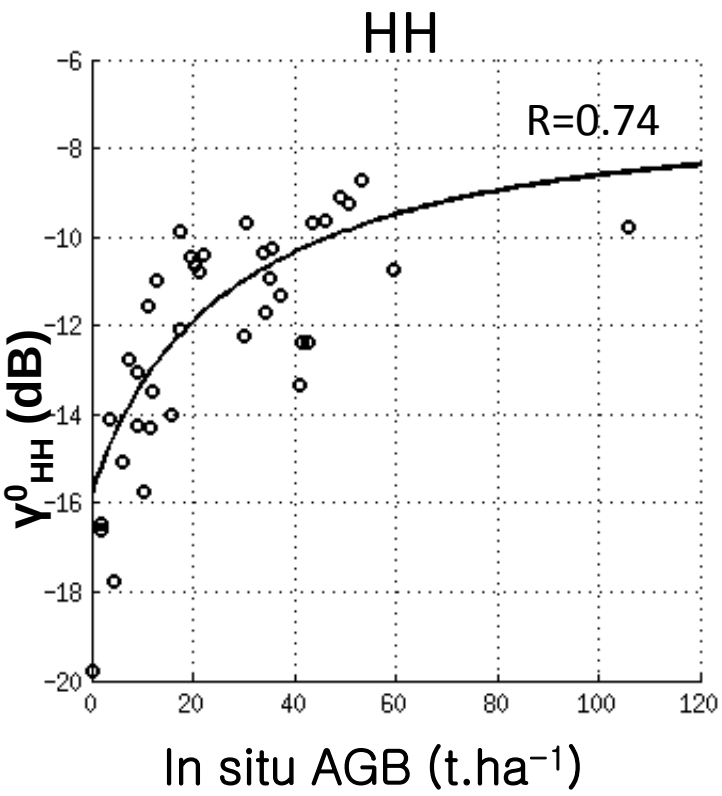
Landsat tree cover pixels > 90%
to estimate b parameter



Estimation of model parameters

a and c estimated by regressions





Bayesian inversion

For a pixel with a backscatter equal to γ^0_{obs} , we estimate the above-ground biomass by using the AGB estimator that minimises the mean square error:

$$\mathrm{AGB}_{\mathrm{estim}} = E\left[AGB\middle|\gamma^0_{obs}\right] = \int_0^{AGB_{\max}} B.p\left(AGB = B\middle|\gamma^0 = \gamma^0_{obs}\right)dB$$

$p\left(AGB = B\middle|\gamma^0 = \gamma^0_{obs}\right)$ is estimated using Bayes theorem:

$$p\left(AGB = B\middle|\gamma^0 = \gamma^0_{obs}\right) = \frac{p\left(\gamma^0 = \gamma^0_{obs}\middle|AGB = B\right)p\left(AGB = B\right)}{p\left(\gamma^0 = \gamma^0_{obs}\right)}$$

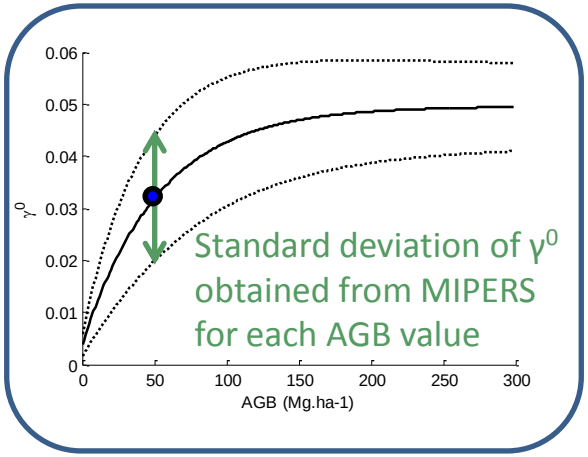
$p\left(AGB = B\right)$ is considered uniform (over the [0 $\mathrm{AGB}_{\max}$] range)

$p\left(\gamma^0 = \gamma^0_{obs}\right)$ is constant in the scene

Therefore: $p\left(AGB = B\middle|\gamma^0 = \gamma^0_{obs}\right) \propto p\left(\gamma^0 = \gamma^0_{obs}\middle|AGB = B\right)$

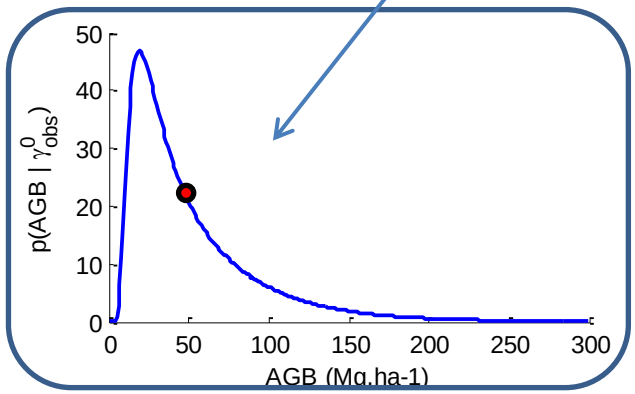
Bayesian inversion

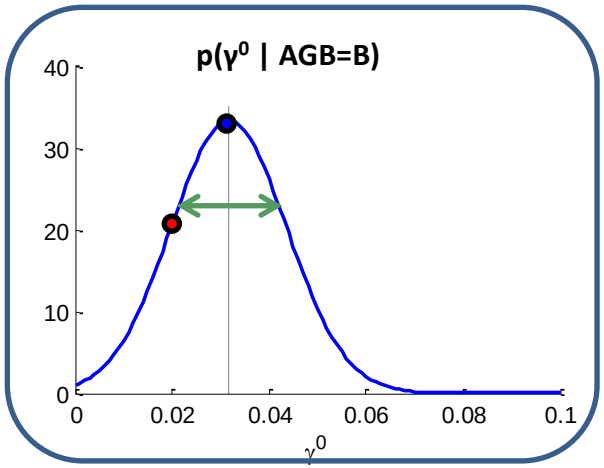
Backscatter variability



Bayesian inversion

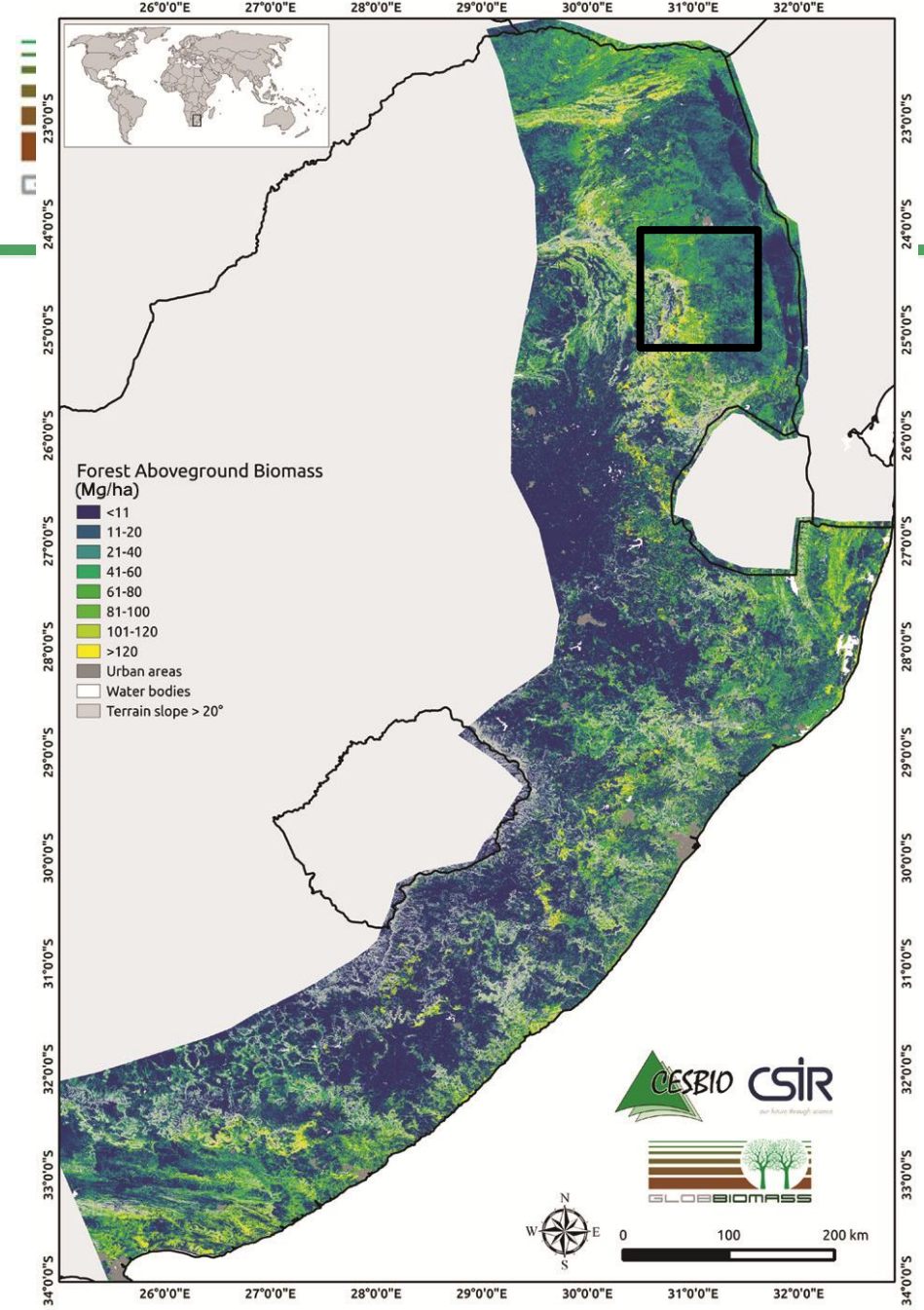
$$\mathrm{AGB}_{\mathrm{estim}} = \int_0^{AGB_{\max}} B.p\left(AGB = B \middle| \gamma^0 = \gamma^0_{obs}\right) dB$$

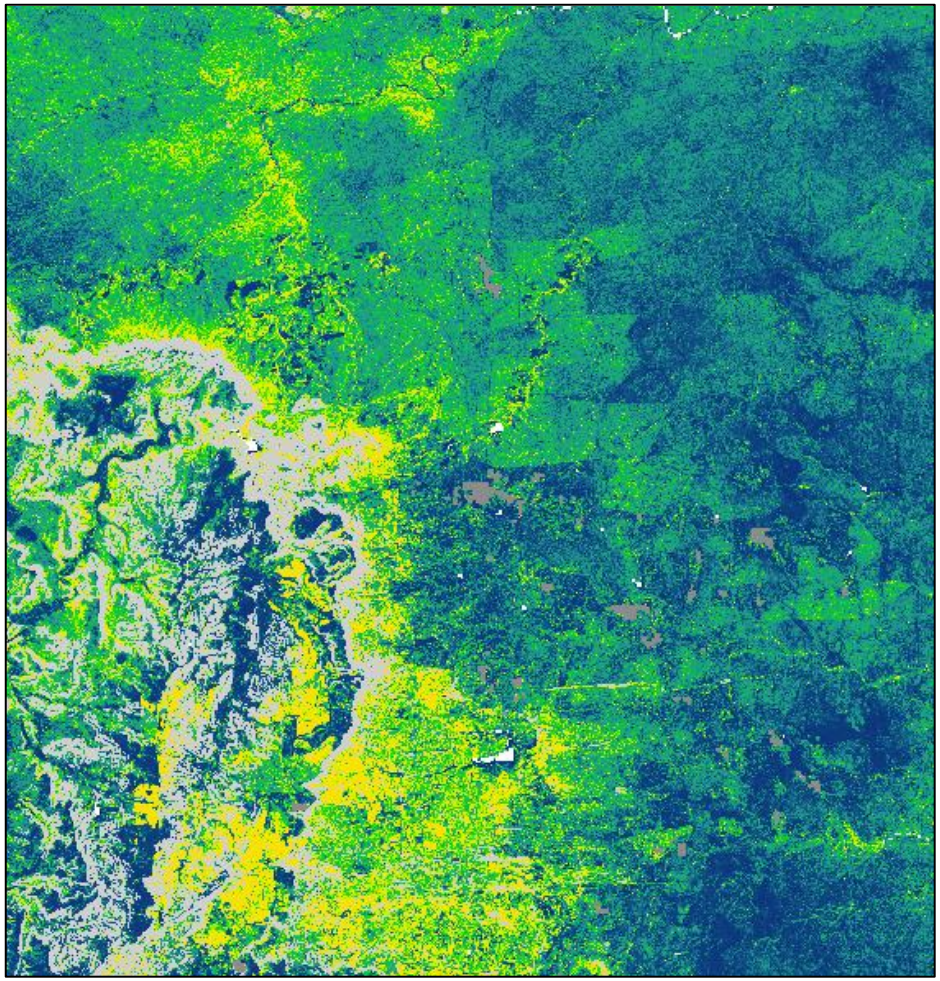




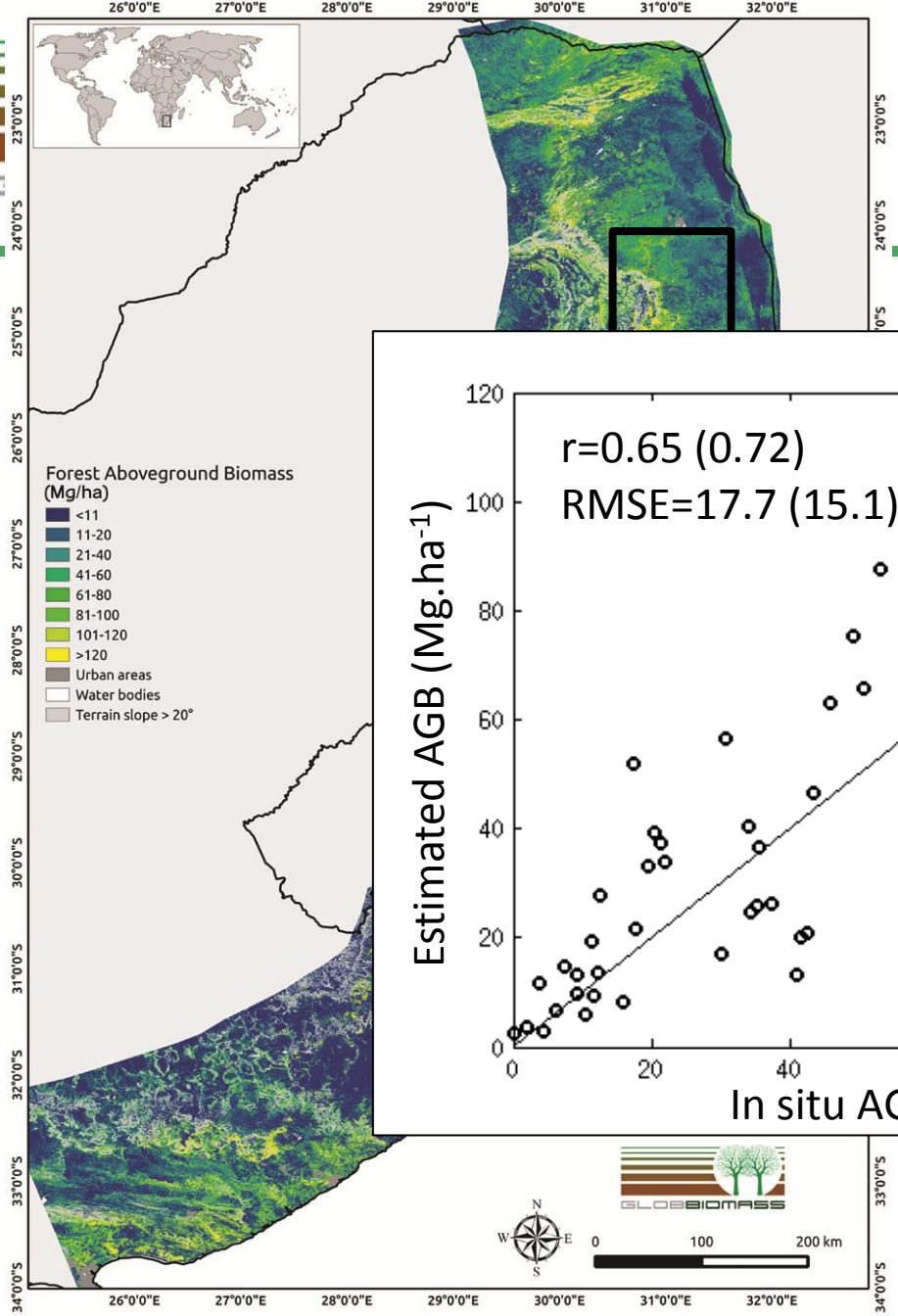
$$p\left(AGB = B \middle| \gamma^0 = \gamma^0_{obs}\right) \propto p\left(\gamma^0 = \gamma^0_{obs} \middle| AGB = B\right)$$

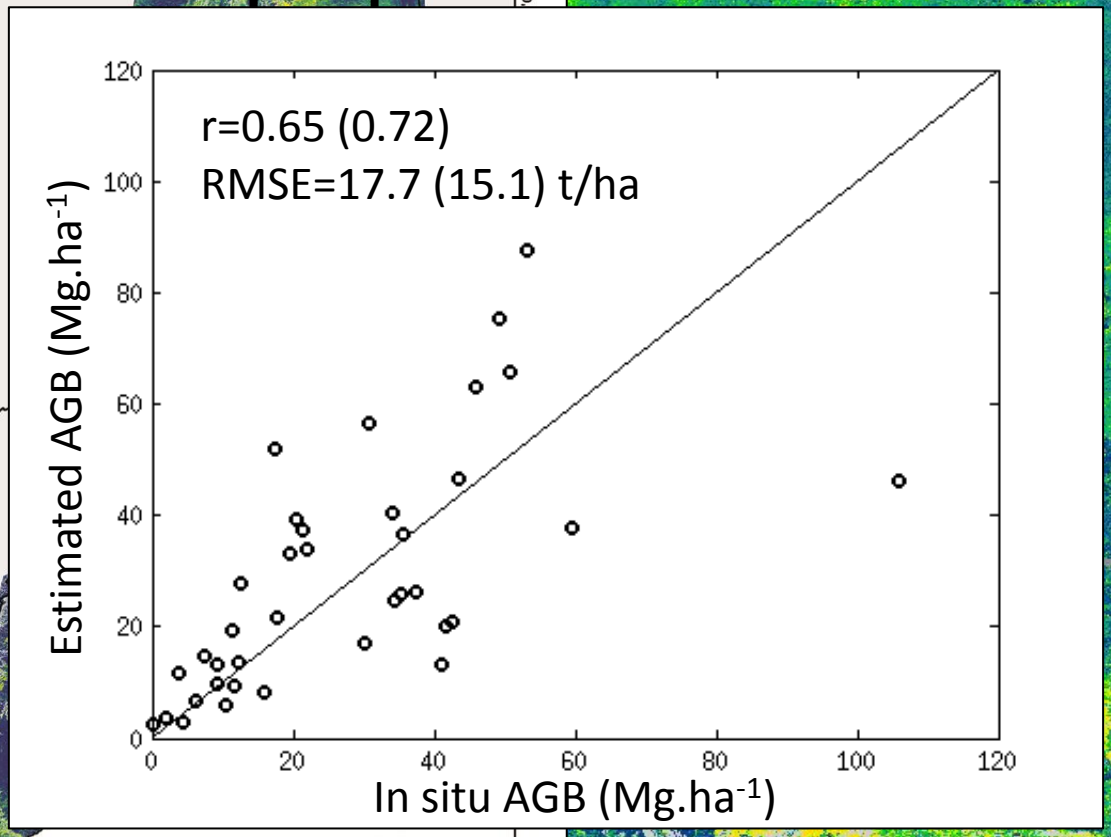
AGB map 2010 at 25m

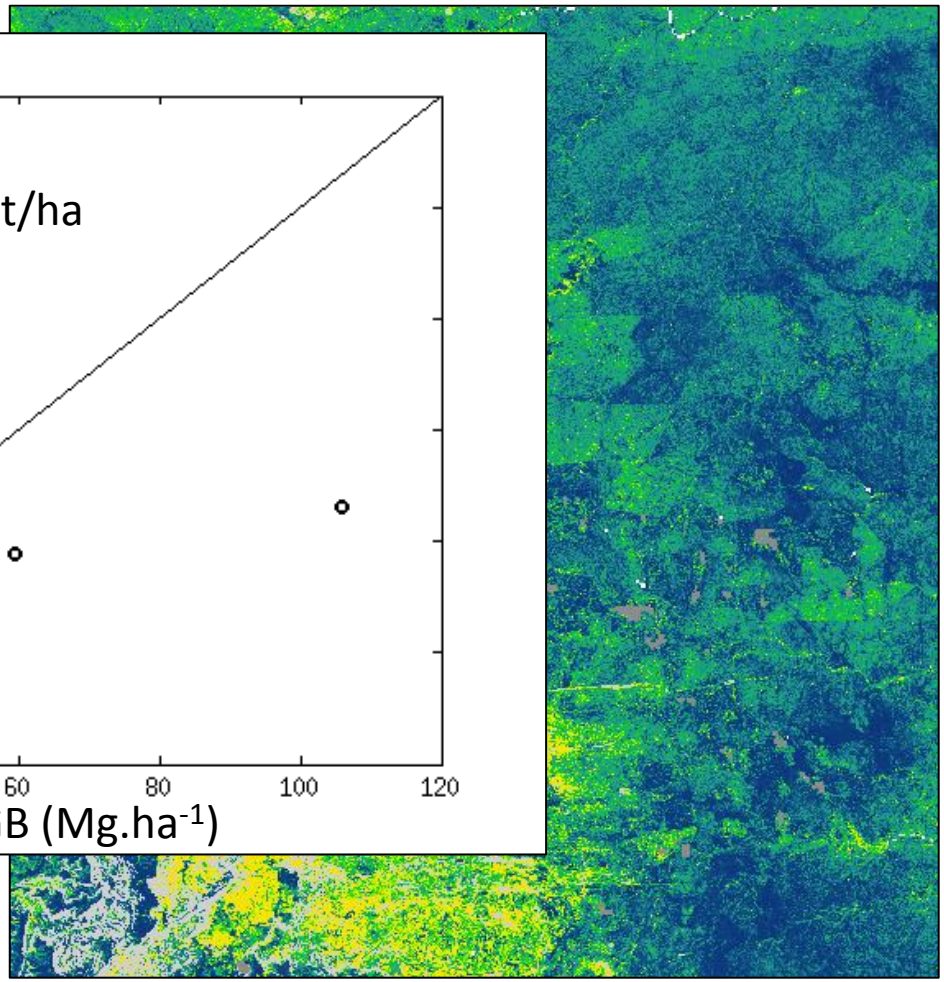




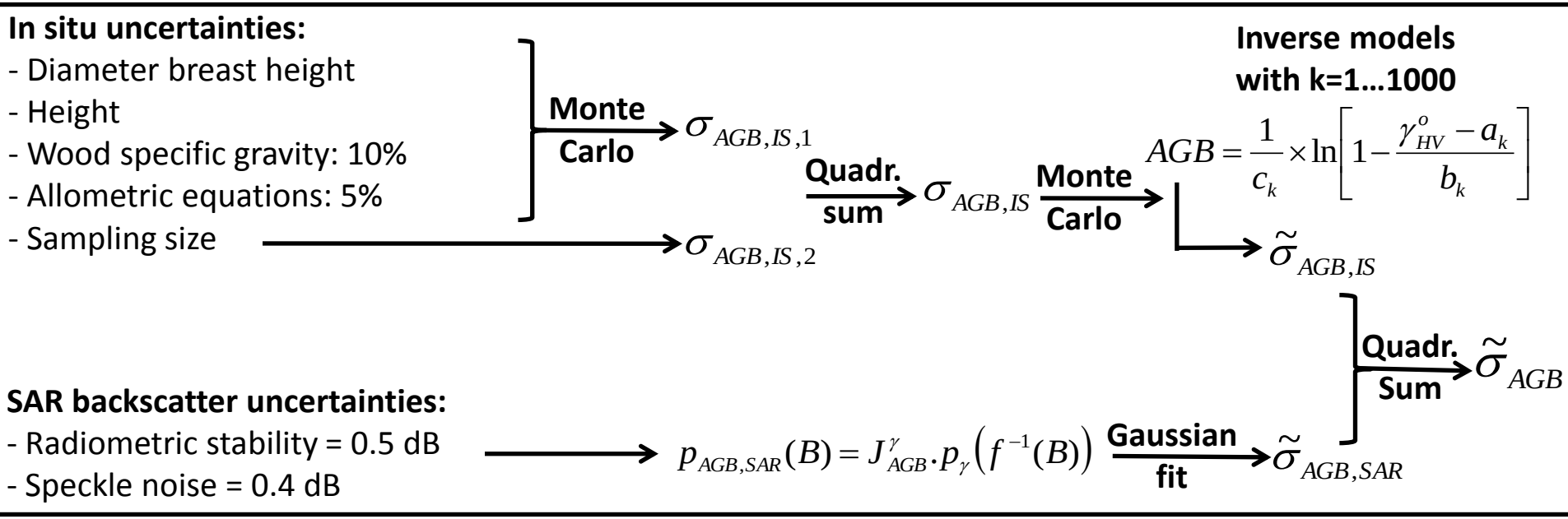
AGB map 2010 at 25m







Uncertainty analysis



- Systematic controls consisted of remeasuring the DBH and the height of a randomly chosen 5% of trees in each plot
- Error due to sampling size for a A-ha plot: b/sqrt(A) (***Réjou-Méchain et al., 2014***)

- Radiometric stability: (***Shimada et al., 2010***)
- The standard deviation of the backscatter γ^o due to speckle is approximately 0.4 dB when the number of looks is approximately 112 .

Plans for 2015 epoch

- Apply the same method on ALOS-2 PALSAR-2 mosaics

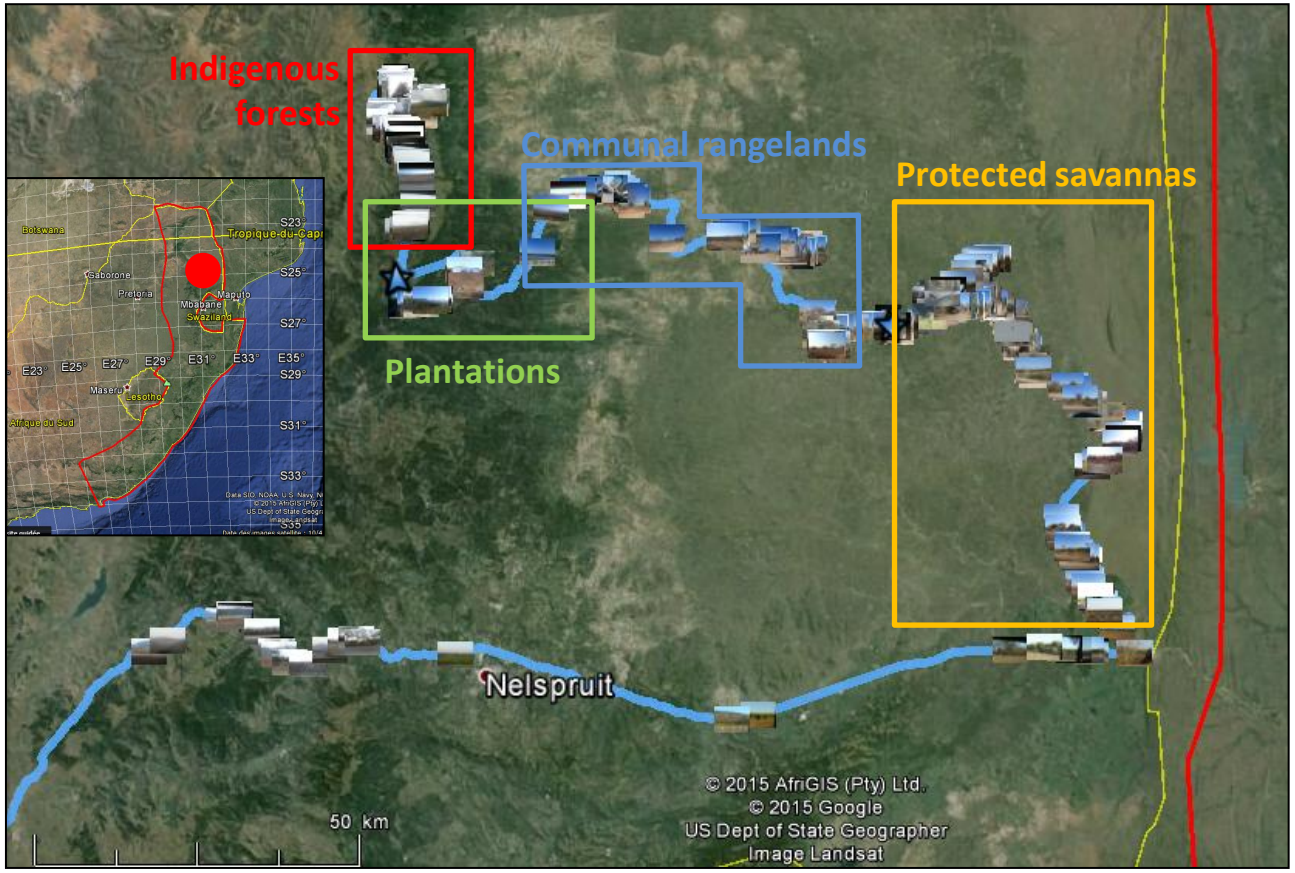
- Ground data collection campaign:

2015-2016: ~30 plots in savanna
~15/30 plots in dense indigenous forests
~15/30 plots in plantations (pine, eucalyptus)
~30 plots in thickets

All the plots have a 1 hectare size.
Better characterization of the other vegetation types.

Field mission in July 2015

Goals:
- design of ground data collection protocol
- site scoping
- collecting georeferenced pictures (over 500 taken)



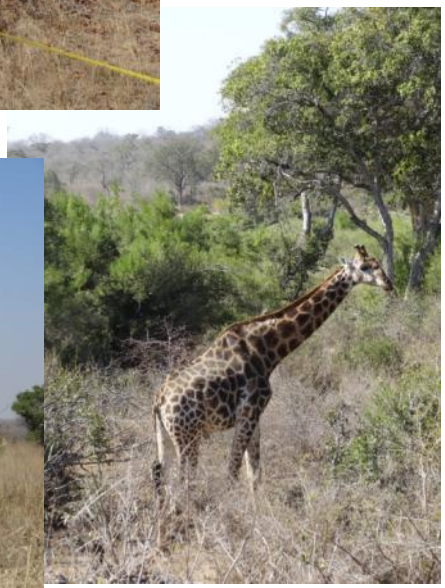
Variety of vegetation types:
- Plantations
- Indigenous forests
- Communal rangelands
- Savannas (protected areas)

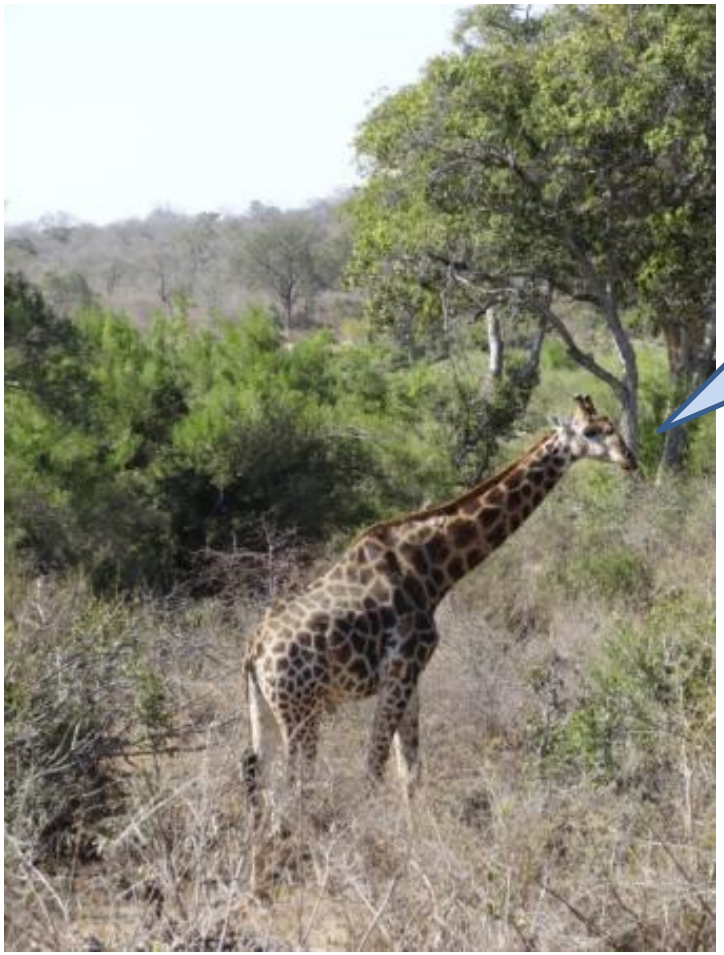
Plantations (eucalyptus, pine)

Indigenous forests

Communal rangelands

Savannas





Thank you for your attention