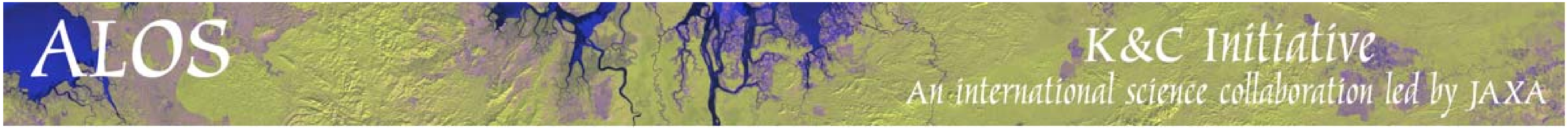
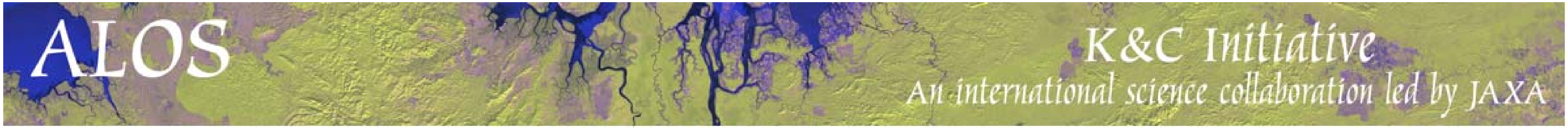


K&C Phase 3

Forest Cover Change and Biomass Mapping

Thuy Le Toan, Stephane Mermoz, Alexandre Bouvet
CESBIO
Toulouse, France



Project Objective

To demonstrate the feasibility of forest information generated from ALOS-PALSAR to support Carbon Cycle Science and International Conventions (REDD) in 3 projects:

1. Forest cover change and biomass mapping in **Vietnam**, where de/af/reforestation have been very active during the last decade. Vietnam is a UNREDD country.
2. Forest cover change and biomass mapping of savanna in **Cameroon**, as a research part of the REDDAF project, also as a contribution to the GEO-FCT, Cameroon being one of the National Demonstrators.
3. Biomass mapping in **African savannas**

Project schedule until end of phase 3

1. Final report of the REDDAF project in Cameroon	Dec-Jan 2014
2. Assessment of a method based on ALOS PALSAR for low resolution biomass mapping of dense tropical forest	March 2014
3. Assessment of forest/non forest mapping in Cameroon	March 2014
4. Complete the validation of African savanna 5. Work on Vietnam forest in HCMC (Alex Bouvet)	Feb 2014

Support to JAXA's global forest mapping effort

The project can support JAXA's global forest mapping effort in Cameroon and in Vietnam and help improve and validate the JAXA forest cover maps.

Ground truth data that will be shared with JAXA

- Vietnam: Ground data at prototype provinces: Hoa Binh , and planned provinces in the South and in the Centre
- Cameroon: Data from REDDAF (Adamawa and Bafia regions of forest-savanna)

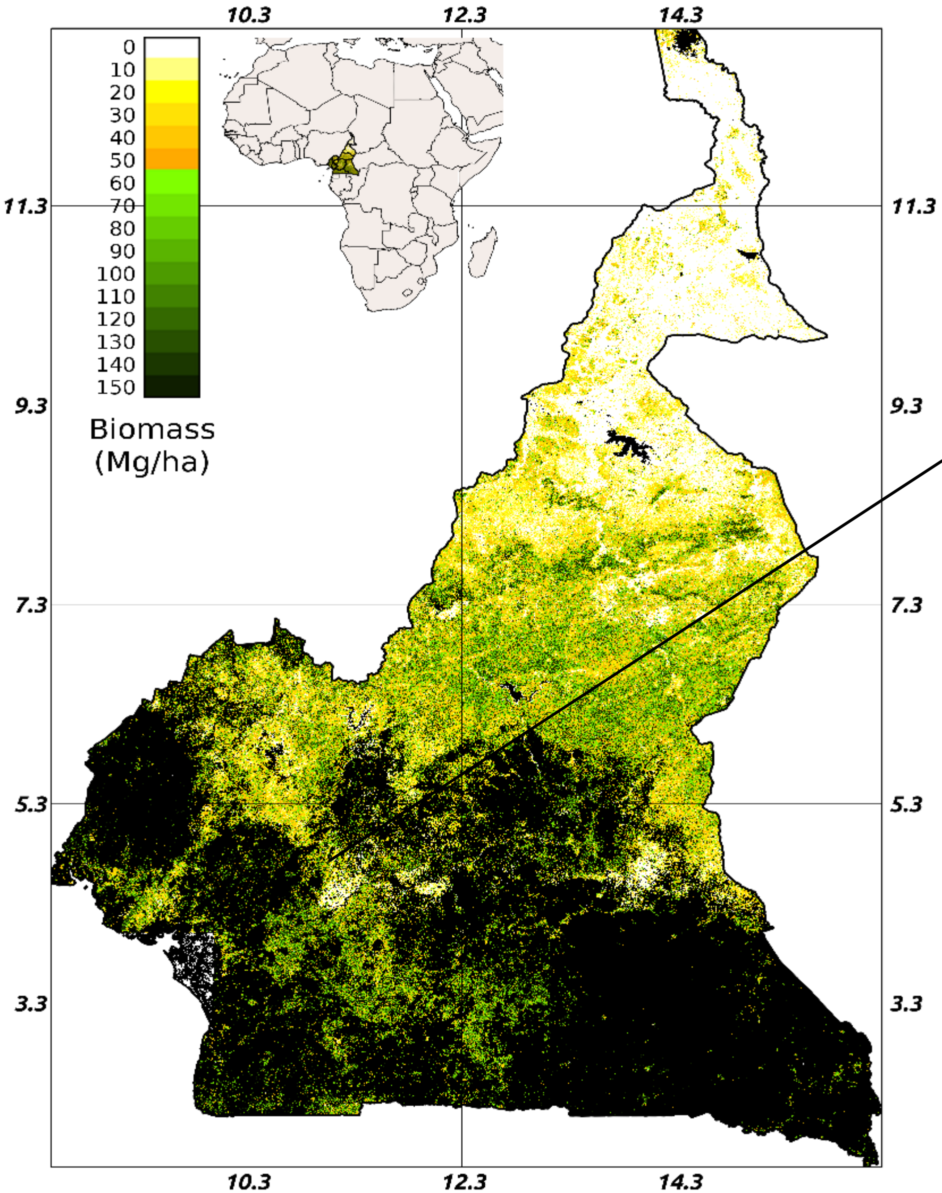
Deliverables and anticipated results

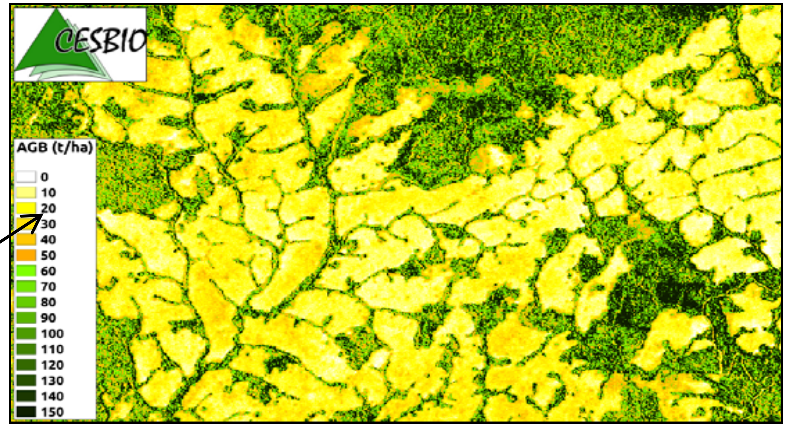
- Forest cover and 2007-2010 cover change in Cameroon
- Biomass of Cameroon savannas
- Forest/non forest map from PALSAR and comparison with results using optical data

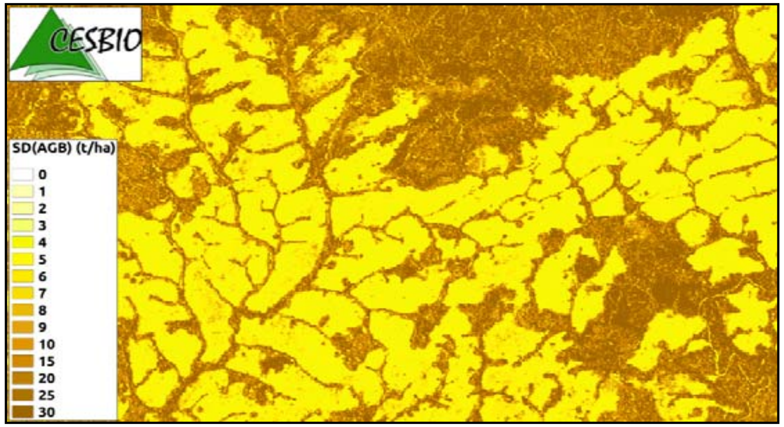
- Papers submitted & in preparation

- *In situ* data in Cameroon and in Vietnam under CESBIO projects

Cameroon Biomass and uncertainties map



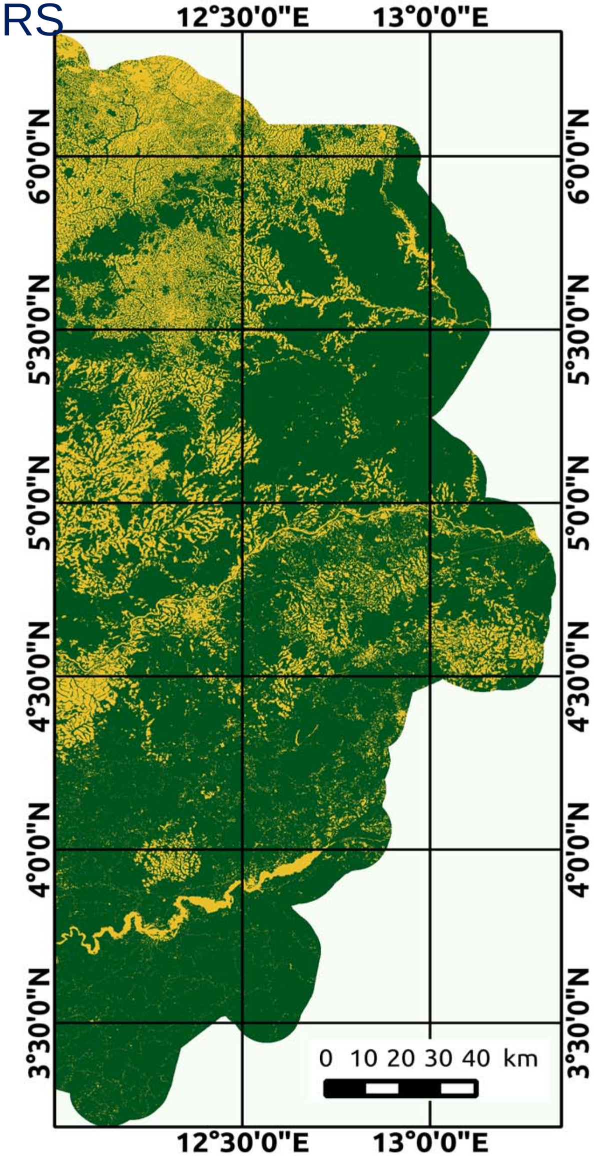




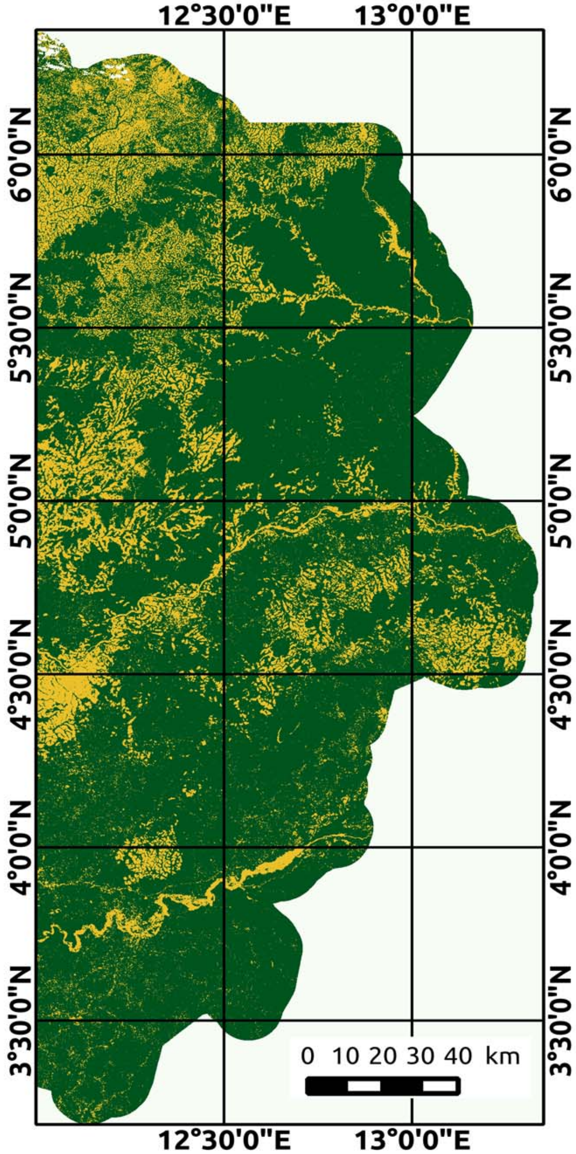
Mermoz S., Le Toan T.,Villard, Rejou-Mechain,M., Seifert-Granzin J. 'Biomass assessment in Cameroon savanna using ALOS PALSAR data', in review RSE

Forest/non forest maps

Map based on Landsat and Rapideye data, developed and validated by SIRS



Map based on PALSAR data data, developed by CESBIO



Use of PALSAR data to map forest/non forest.

E(Prod. accuracy) = 86.8%

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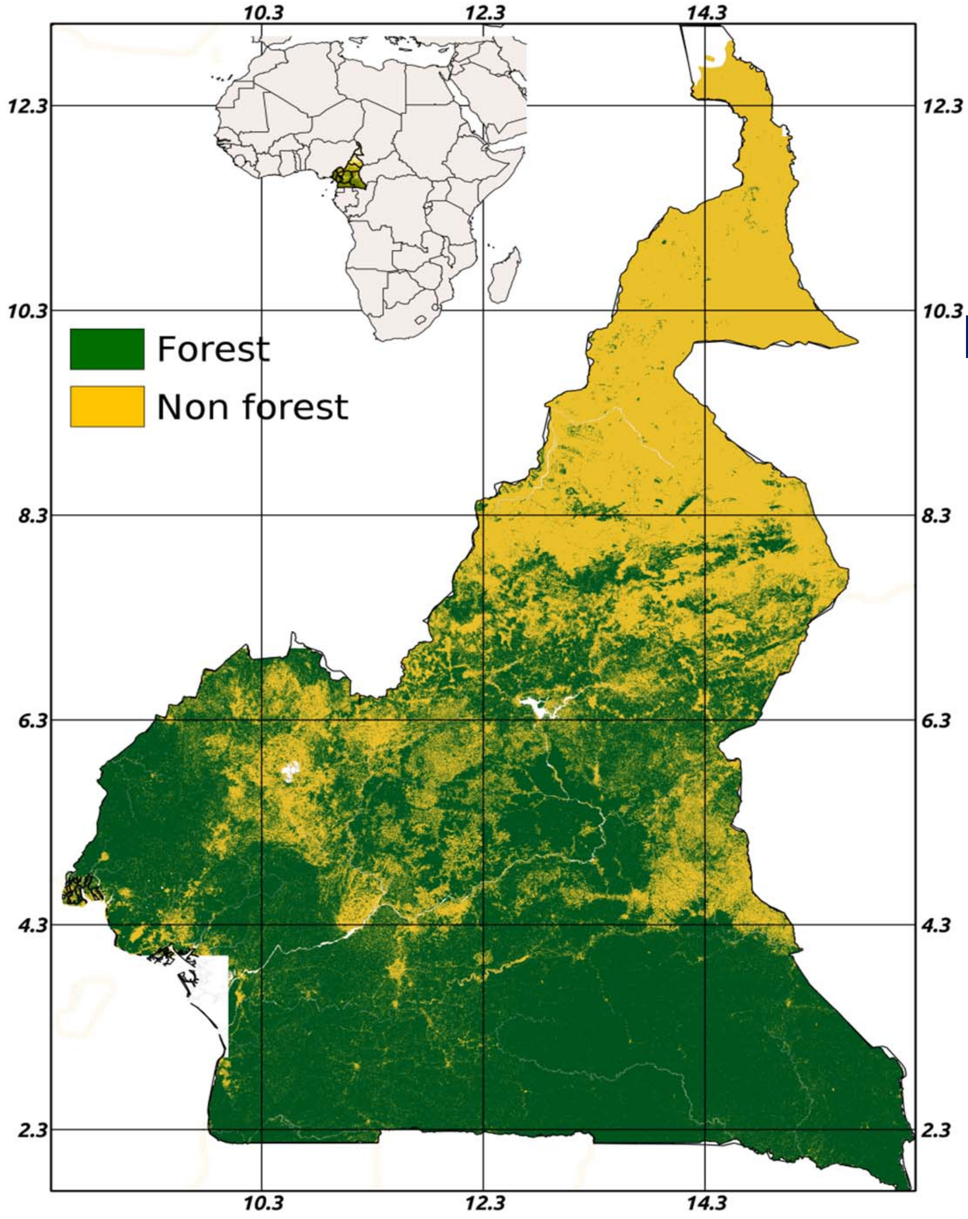

Forest/non forest maps using PALSAR data

Validation in progress

A biomass map of African savannas at a spatial resolution of 100 meters using ALOS PALSAR dual-polarization data

Alexandre Bouvet, *Thuy Le Toan, Stéphane Mermoz*
CESBIO, Toulouse, France

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K&C Phase 2: the African mosaic

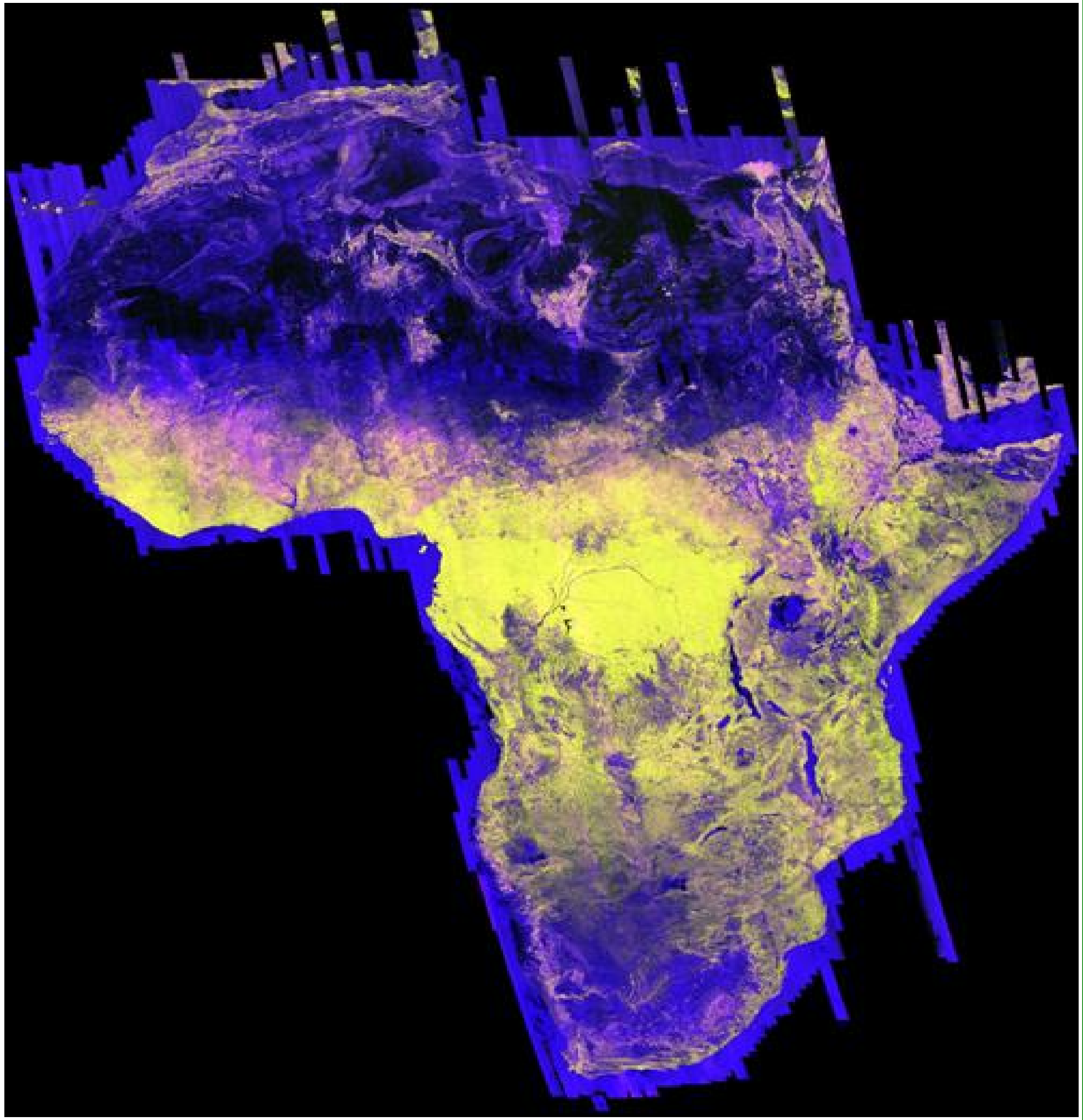
Global coverage of the African continent with PALSAR observations at two polarizations (HH + HV), one date (mainly May-August 2007)

De Grandi GF, Bouvet A., Lucas R., Shimada M., Monaco S., Rosenqvist A., IEEE TGRS, vol.49 n.10, Oct. 2011

JRC
EUROPEAN COMMISSION

De Grandi GF ⇨ retired in 2012
Bouvet A ⇨ finished postdoc at JRC in 2012
No Phase 3 for JRC!

But: now at CESBIO
Opportunity to keep working on the mosaic.



Savanna ecosystems in Africa

• African ecosystems: sources of **interannual variability** in the global atmospheric CO_2

• Recent estimates of C balance in Africa varied from a **sink** of 3.2 PgC. yr^{-1} to a **small source** (Ciais et al., 2011)

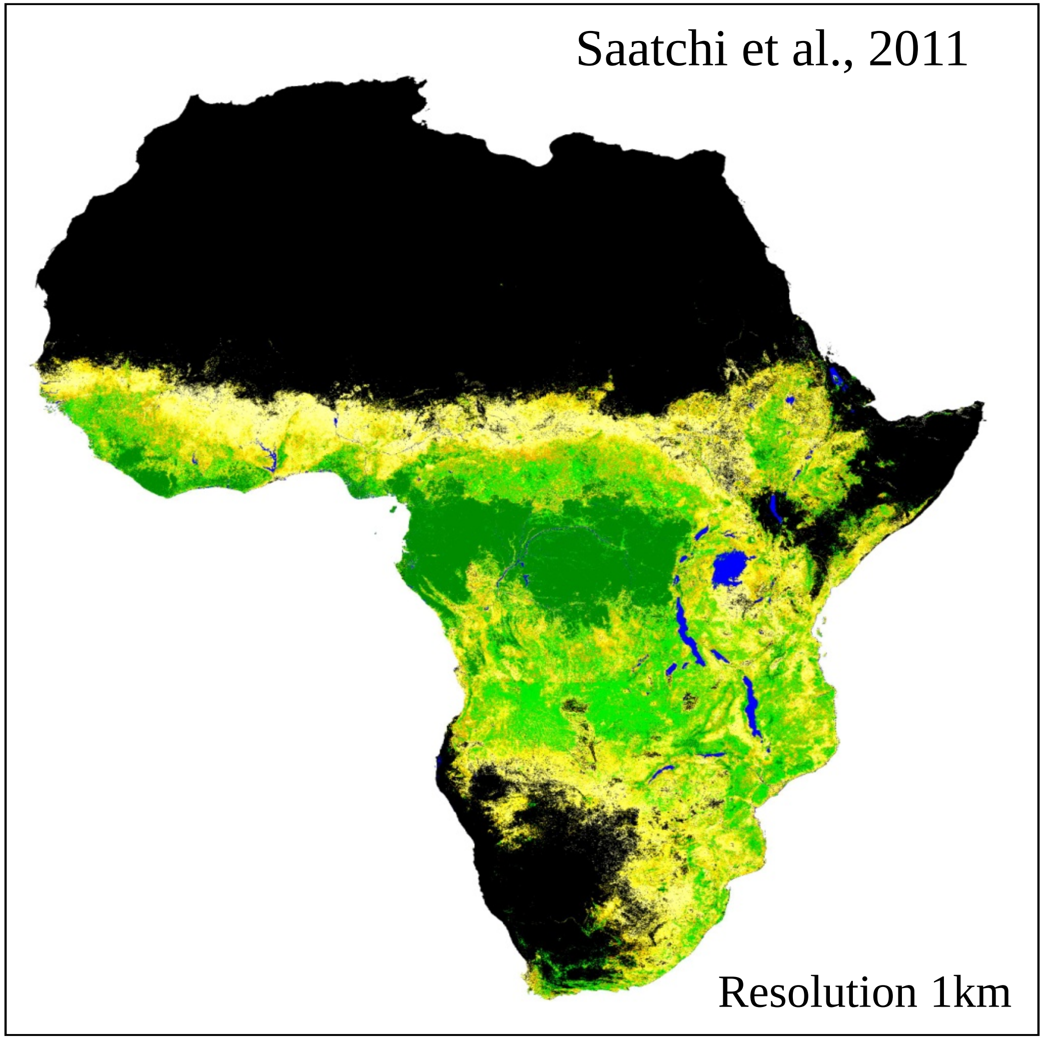
• **Shrublands and savannas** cover 50% of the African continent, and represent **46% of the carbon storage** (only 16% in Latin America and Southeast Asia) (Baccini et al., 2012)

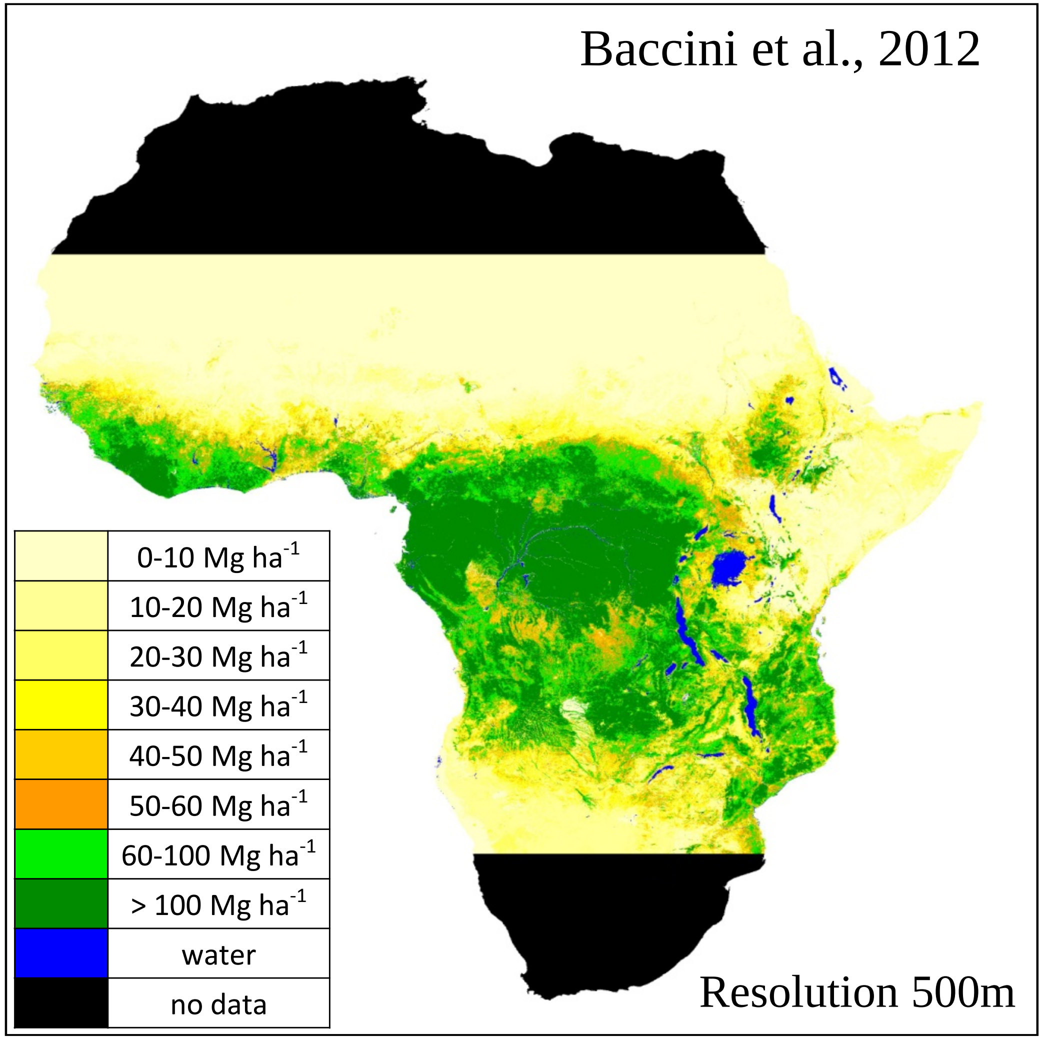
• Dense forests spared by massive deforestation (deforestation rate 0.05% in Congo) but **more rapid deforestation in savanna woodland** (e.g. 2.75% in Uganda) for 2005-2010 (FAO 2010)

⇨ Need to quantify carbon stocks and changes in savanna ecosystems to determine the direction of carbon budget in Africa (sink or source).

Existing biomass maps

Existing large scale biomass maps are designed primarily for tropical areas and higher biomass ranges (forests).

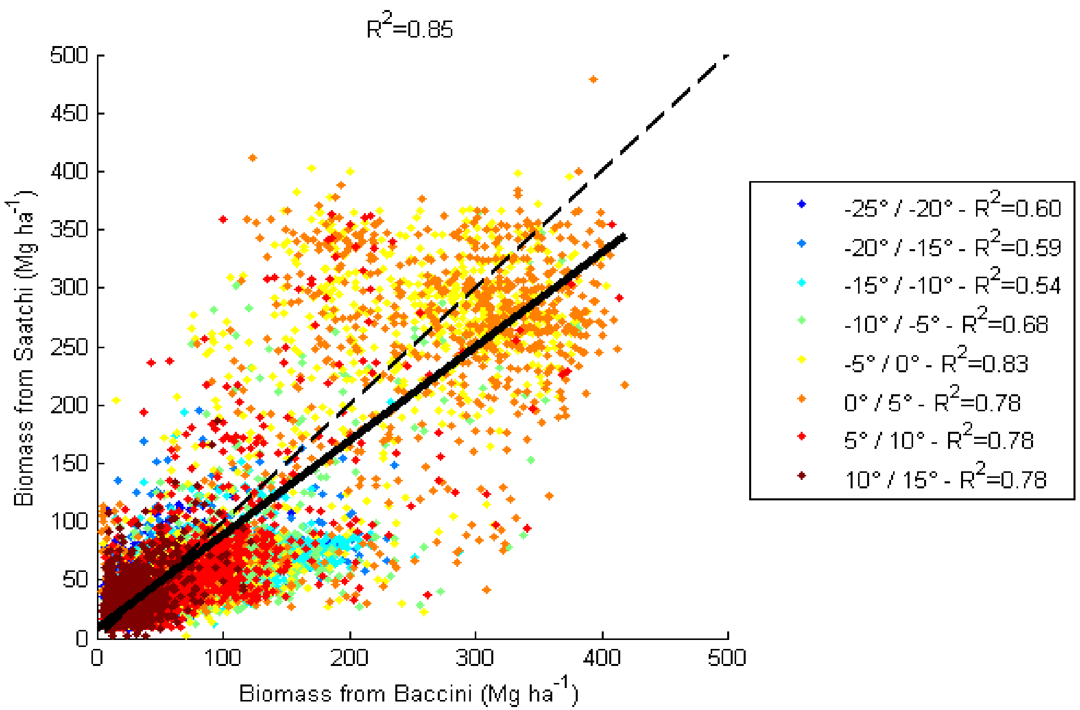


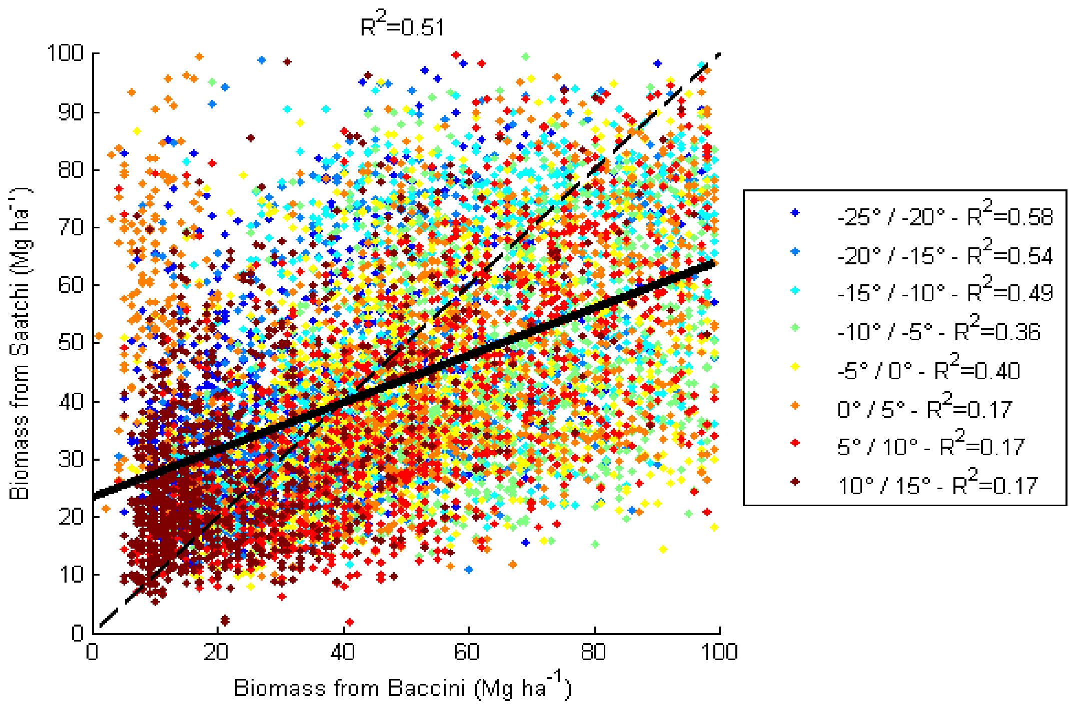


Existing biomass maps

The overall agreement between the 2 maps is good (R^2=0.85), but poor in the 0-100 Mg ha^{-1} biomass range.

The biomass of African savannas is poorly known.





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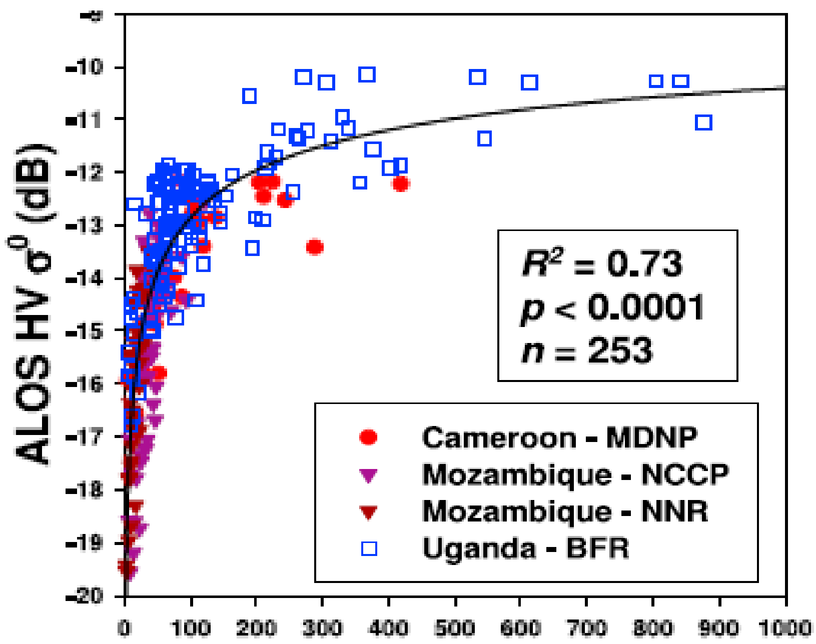
L-band SAR for biomass retrieval

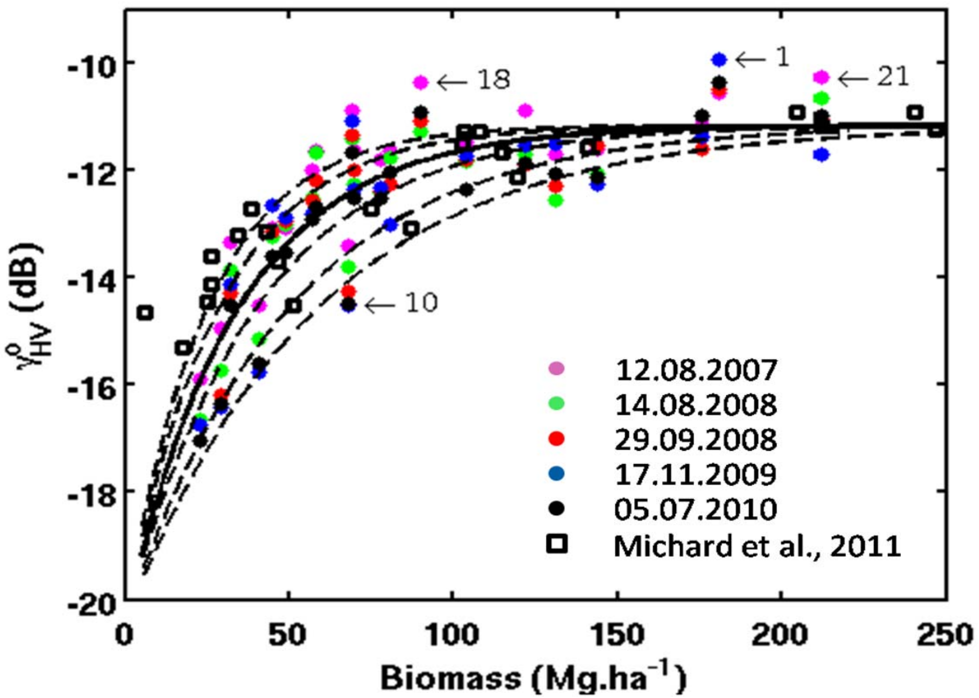
L-band has a strong potential to retrieve the biomass of savannas (HV polarisation).

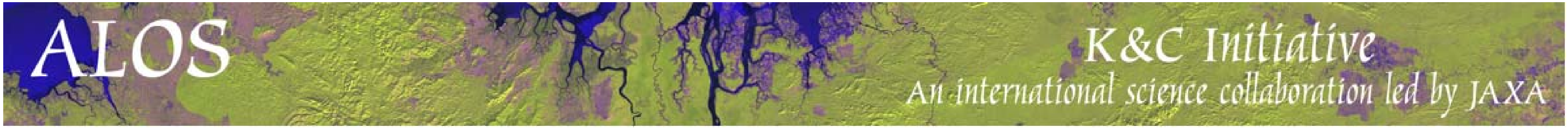
Saturation reported around 70-150 Mg ha^{-1}

Mitchard et al., GRL, 2009



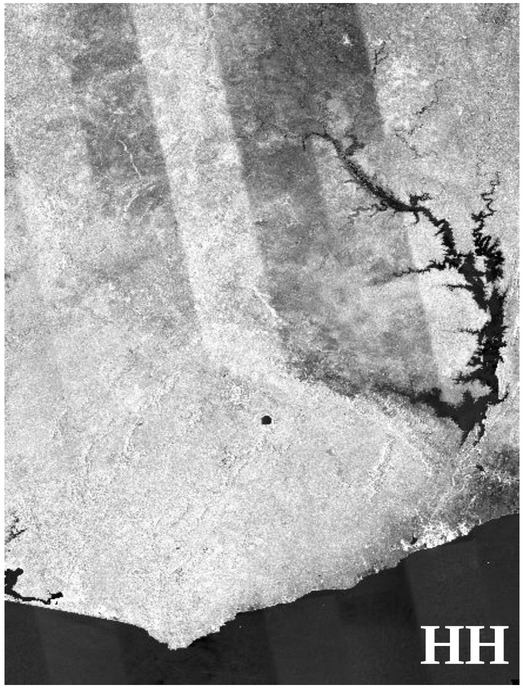
Mermoz et al., RSE, 2013

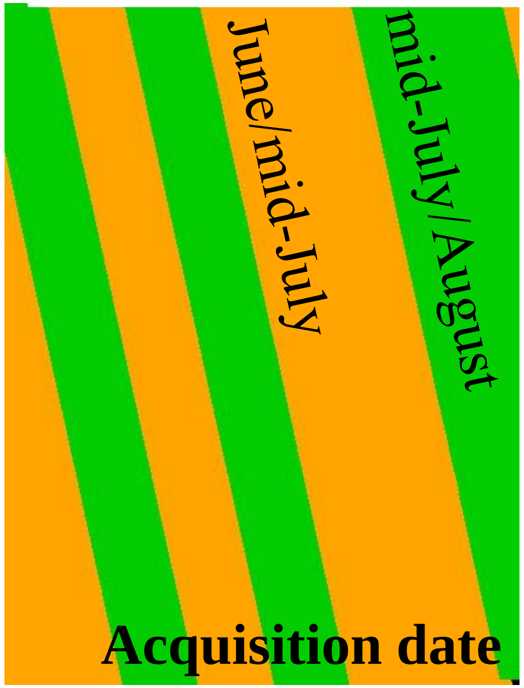


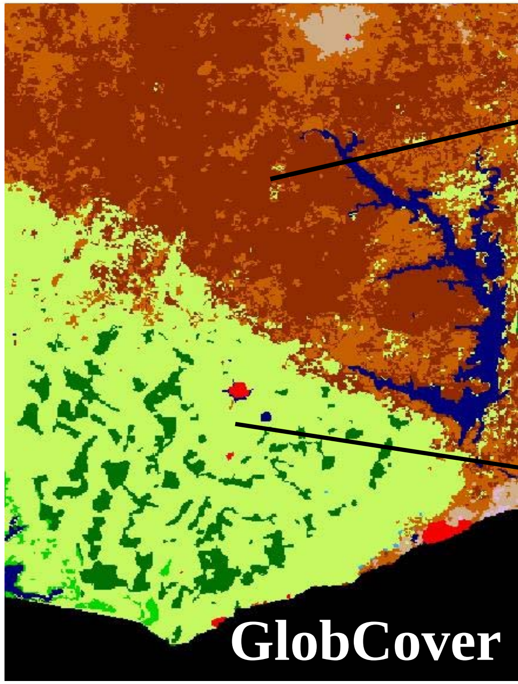


Environmental effects

In Western Africa, the first weeks of June are still dry season, wet season starts around mid-June.







Deciduous shrublands and woodlands

Mosaic Forest/Cropland and Evergreen forest

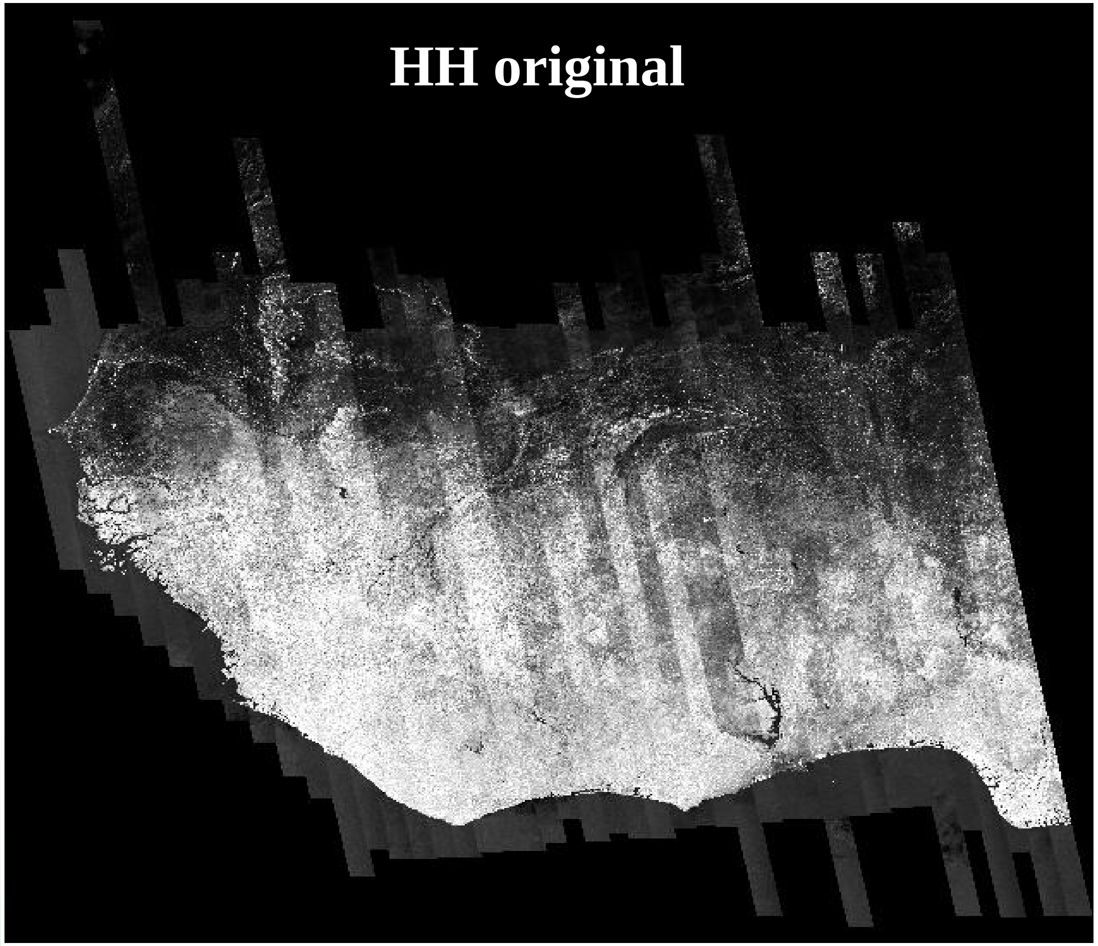
Environmental effects : soil moisture, vegetation water content.
Visible mostly in open areas.

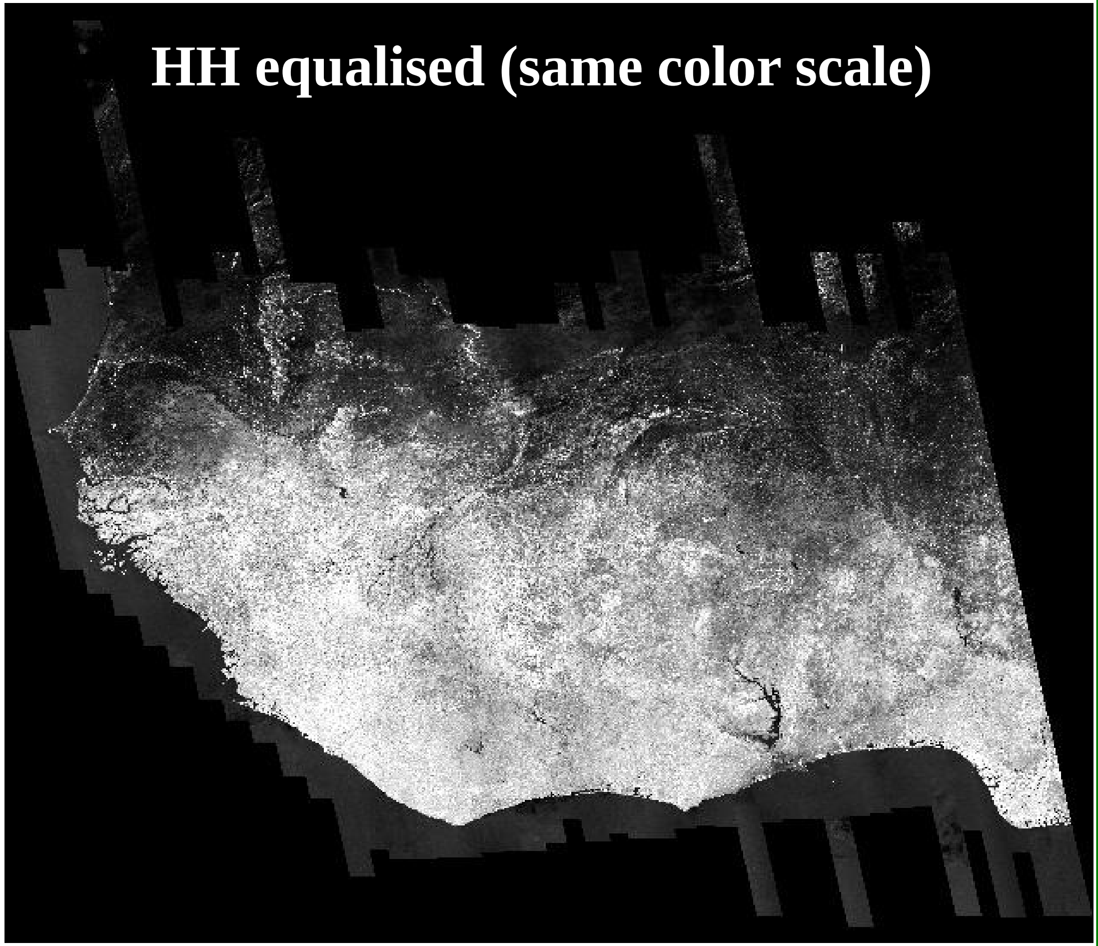
Removal of environmental effects

Data acquired at different dates are equalised to look as if they were taken at the same date.

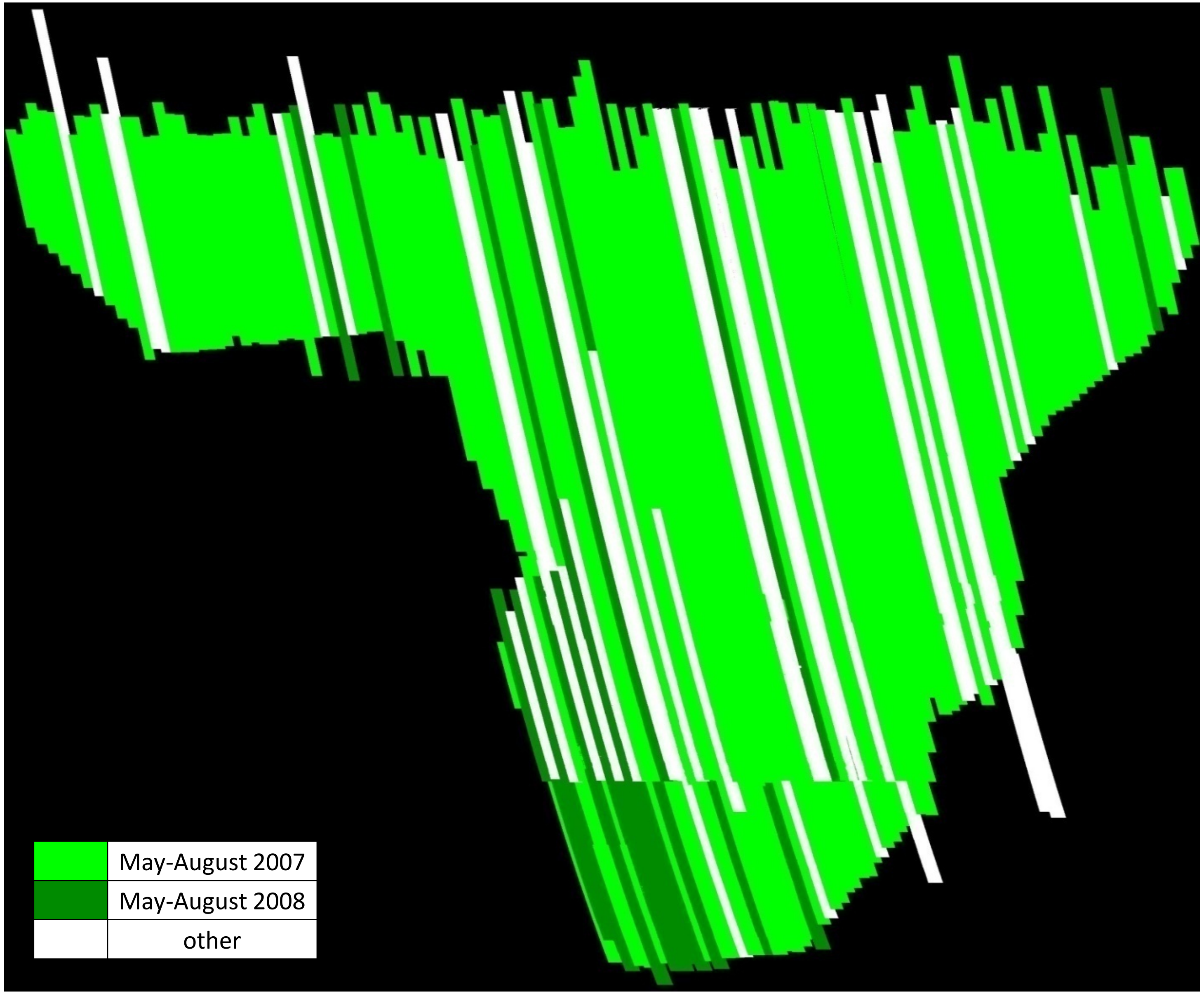
Pros: visual and automatic interpretation

Cons: loss of geophysical information





Acquisition dates



Most acquisitions are concentrated in the May-August period.

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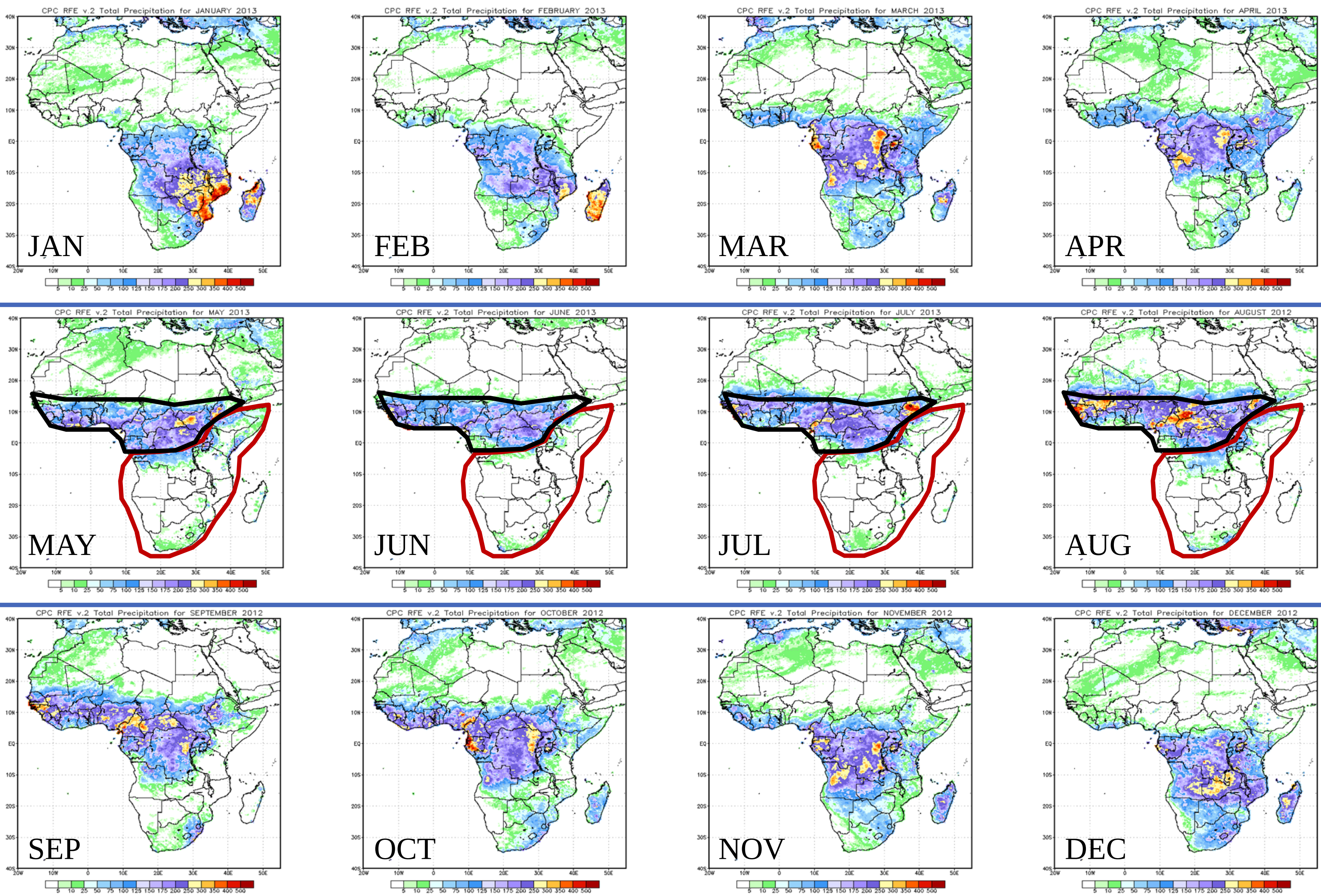
Monthly precipitation

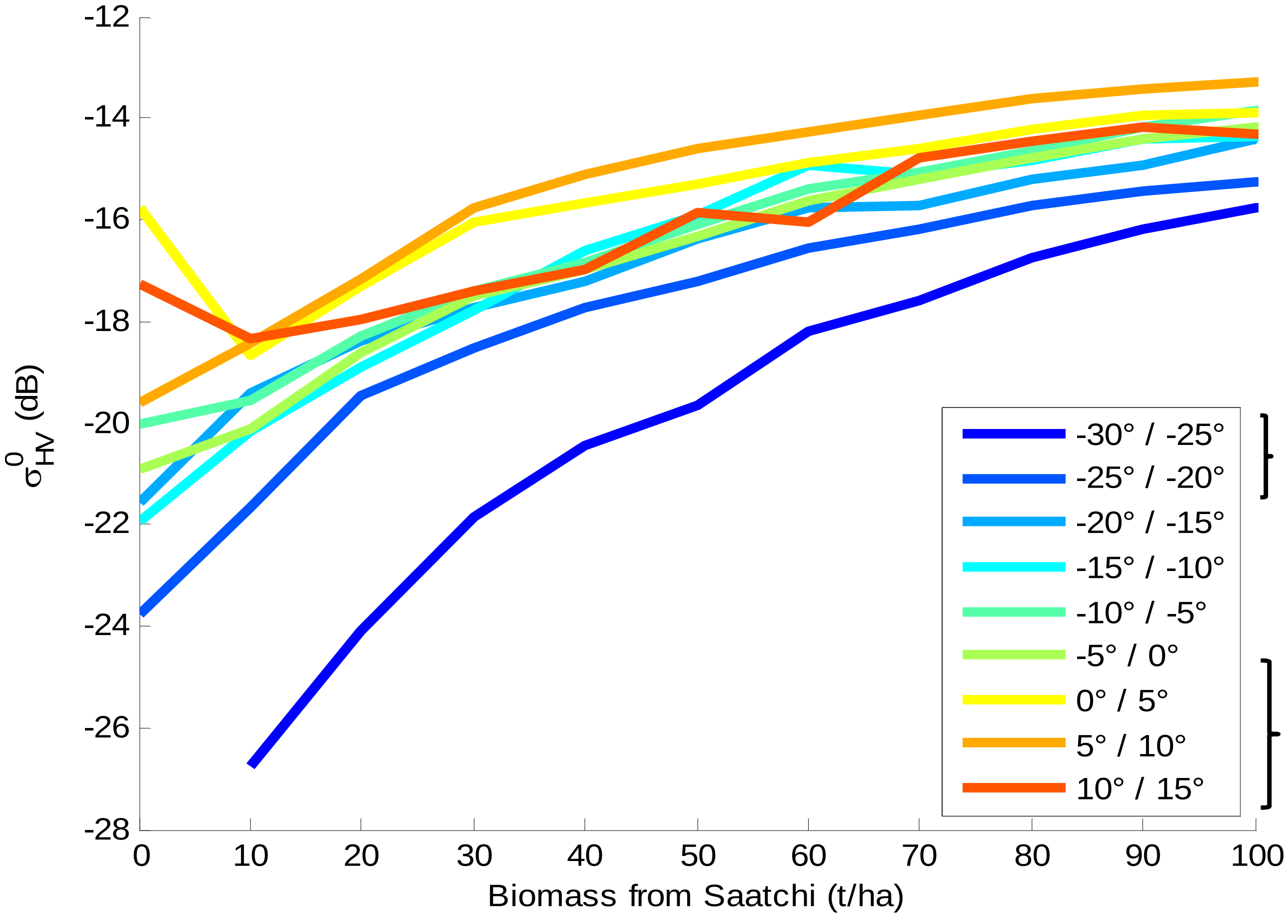


From National Weather Service – Climate Prediction Center

In May-August, the dry season areas are Eastern and Austral Africa

Seasonality

The HV vs biomass relationship is not the same in the dry season and in the wet season.
In very open areas, the total backscatter is dominated by the ground backscatter.
In the wet season: soil moisture is higher, hence the ground backscatter is higher.
⇨ Lower dynamic range in the wet season.



Lower latitudes ⇨ Dry Season
⇨ High dynamic range

Higher latitudes ⇨ Wet Season
⇨ Low dynamic range

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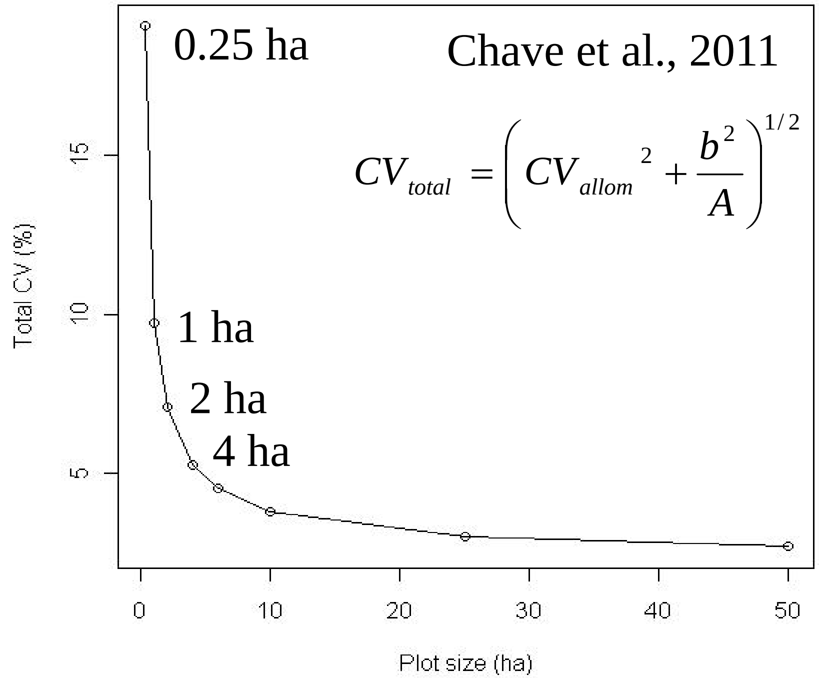
Approach

• Our goal is to relate the HV backscatter to the biomass of savannas and woodlands

• A collection of field plots are used.
Biomass is calculated from allometric equations.
Plot size: at least 0.25 ha (ideally, more than 1 ha).
⇨Most existing plots are not adapted

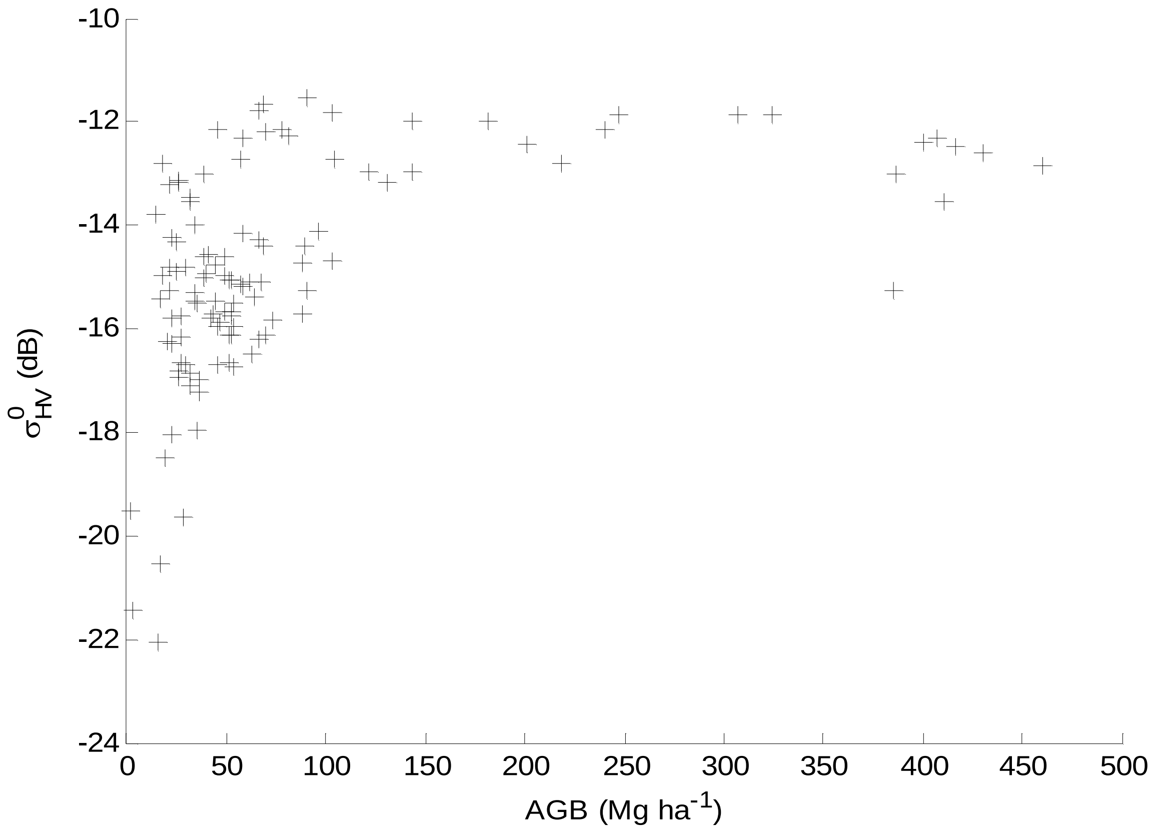
Effect of plot size, tropical forest



•For each field plot, we calculate the HV backscatter in a 3x3 window around the plot. The homogeneity of the 3x3 window is assessed (coefficient of variation).

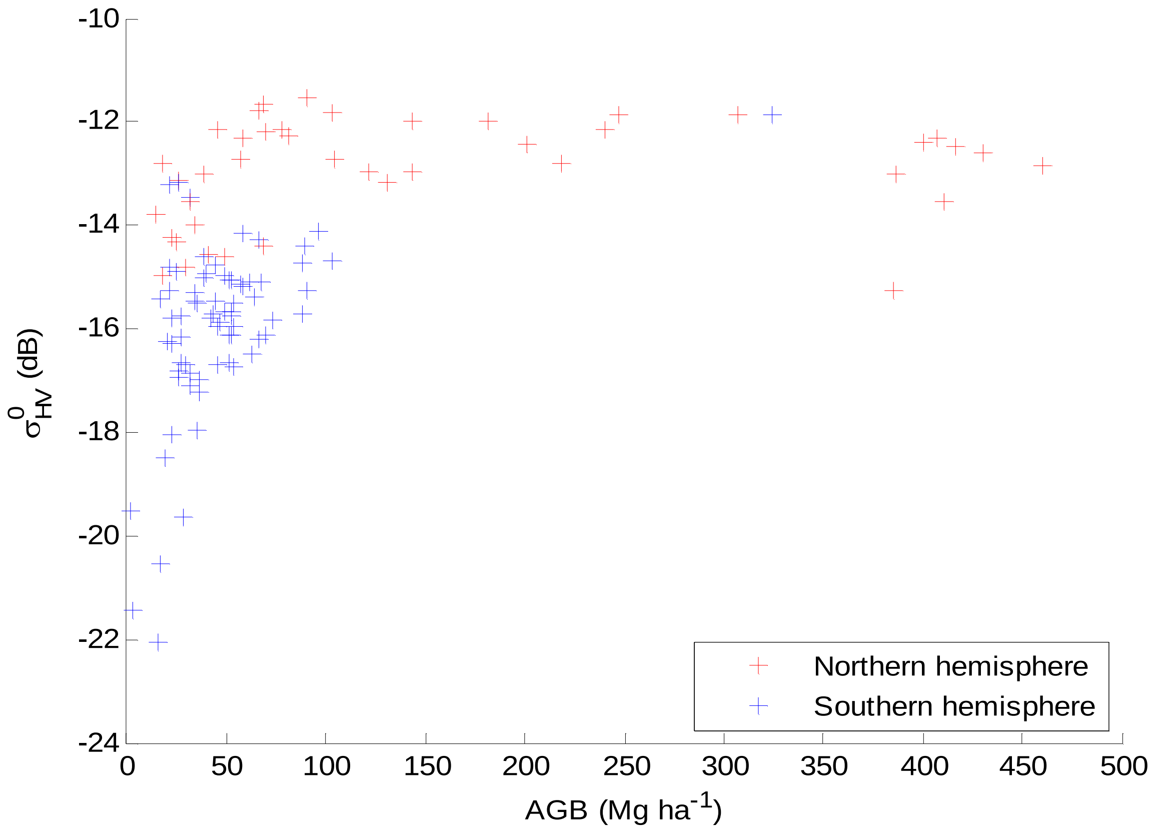
Method

Biomass field plots: 110 plots bigger than 0.25 ha.
(Smaller plots are discarded before any analysis.)



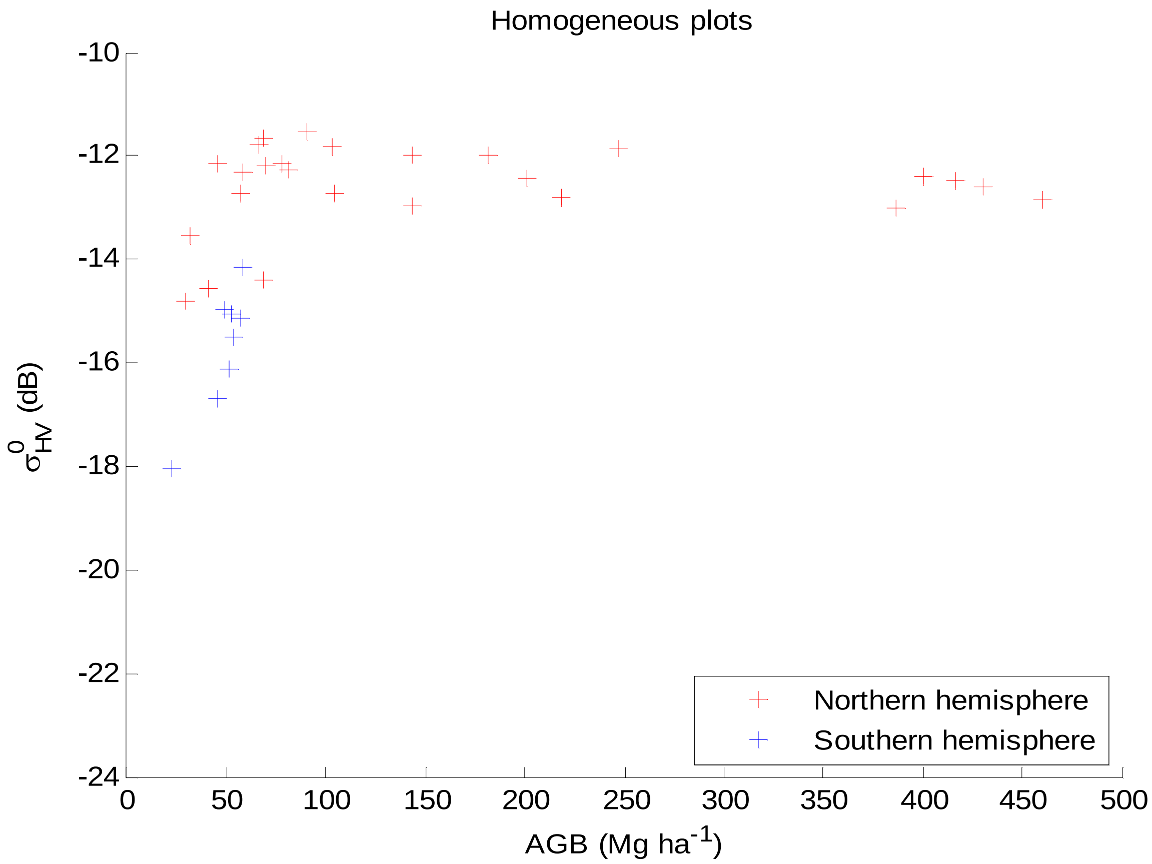
Method

Seasonality effects are present.



Method

Selection of plots which fall in an homogeneous area in the PALSAR mosaic.



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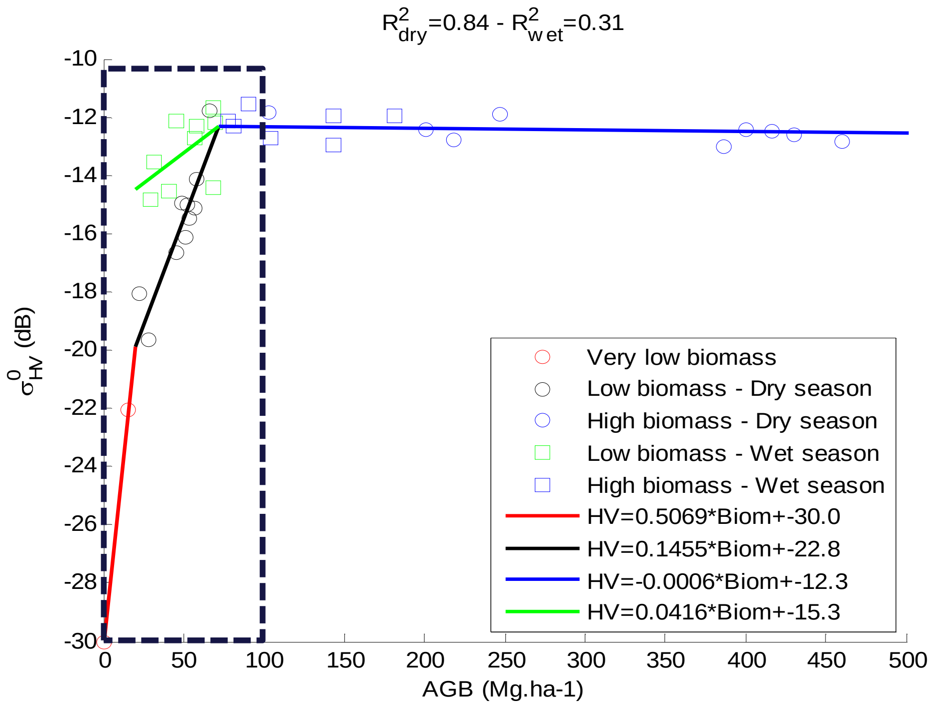
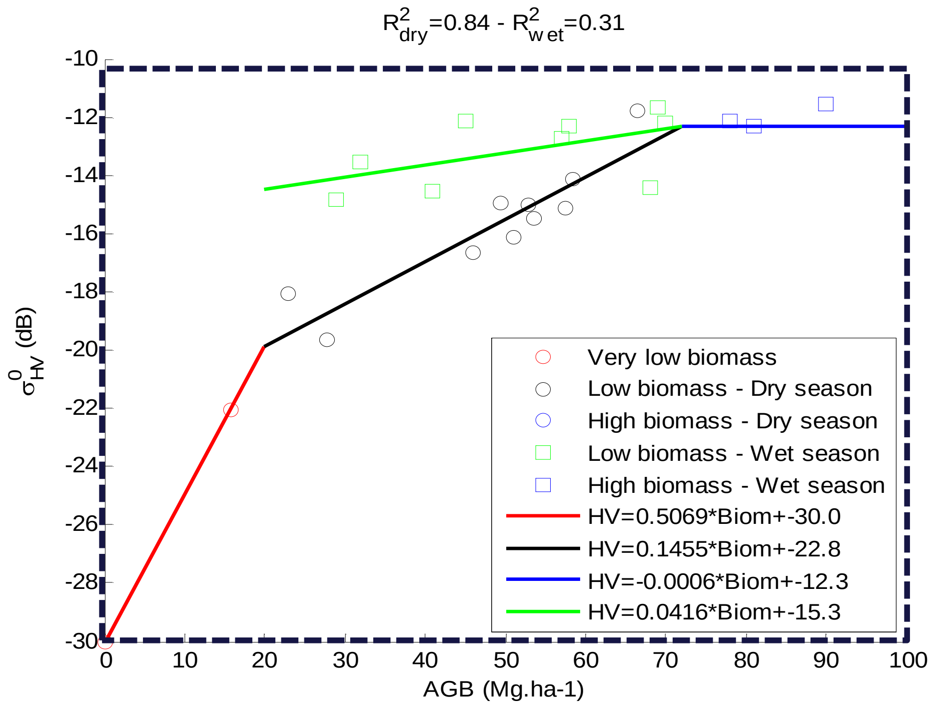
Backscatter vs AGB relationships





Wet season: Cameroon [1]

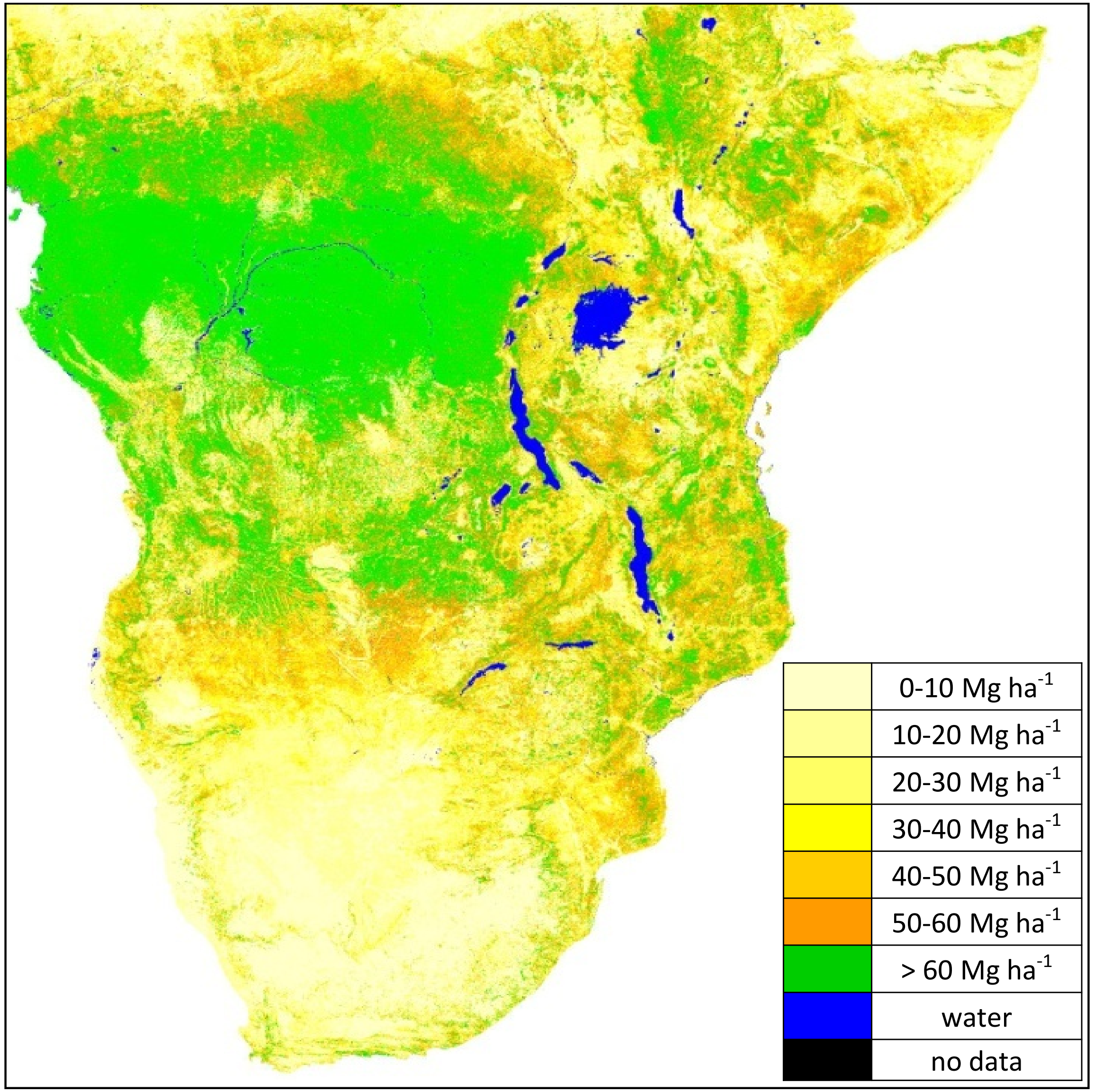
Dry season: Uganda, Mozambique [2], Botswana and South Africa [3]

[1] Mermoz, S., et al., 2013, Biomass assessment in Cameroon savanna using ALOS PALSAR data, *Remote Sensing of Environment*, accepted

[2] Mitchard, E.T.A., et al., 2009. Using satellite radar backscatter to predict above-ground woody biomass: A consistent relationship across four different African landscapes. *Geophysical Research Letters*, 36, L23401

[3] Scholes, R. J. 2005. SAFARI 2000 Woody Vegetation Characteristics of Kalahari and Skukuza Sites. Data set. Available on-line [http://daac.ornl.gov/]

Results

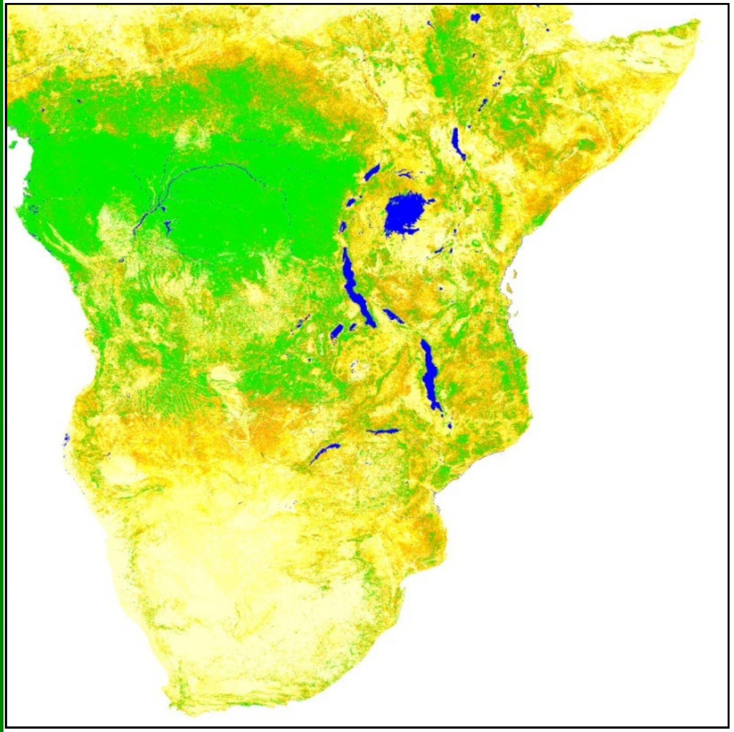


Biomass inversion using the Dry Season regression

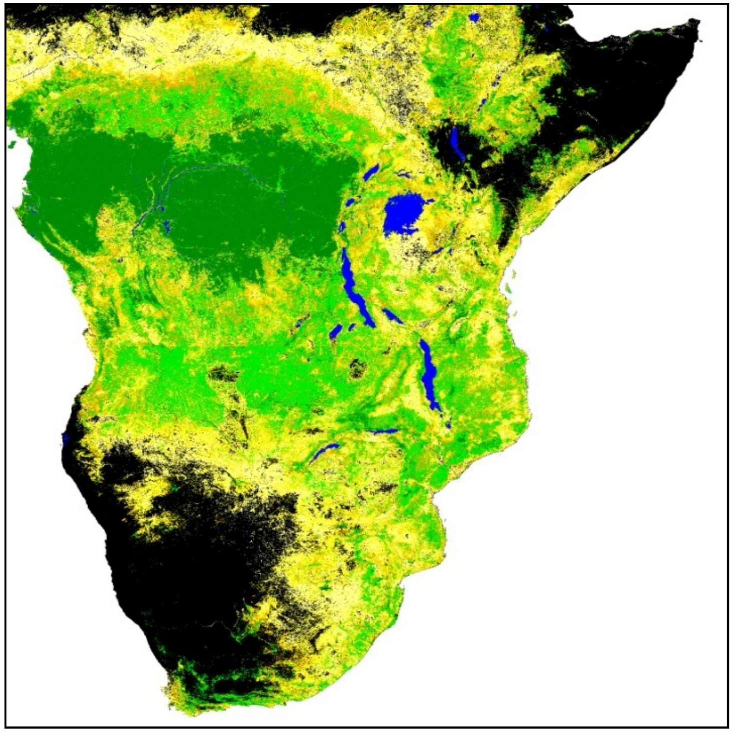
Supposed validity domain: Eastern and Austral Africa

Comparison with existing maps

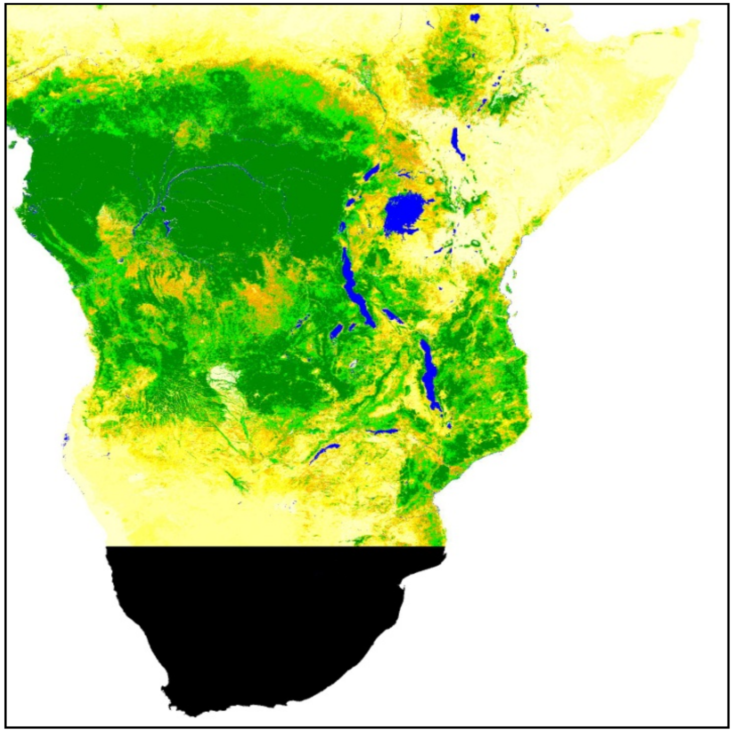
This study



Saatchi et al., 2011



Baccini et al., 2012



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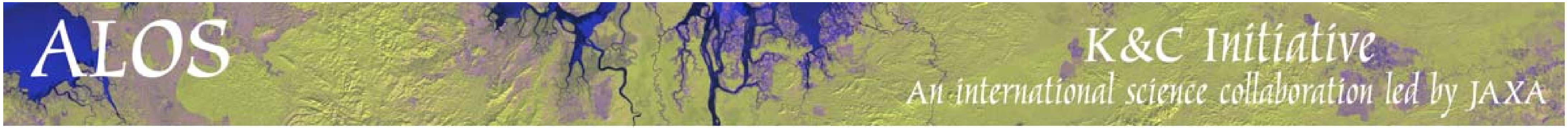
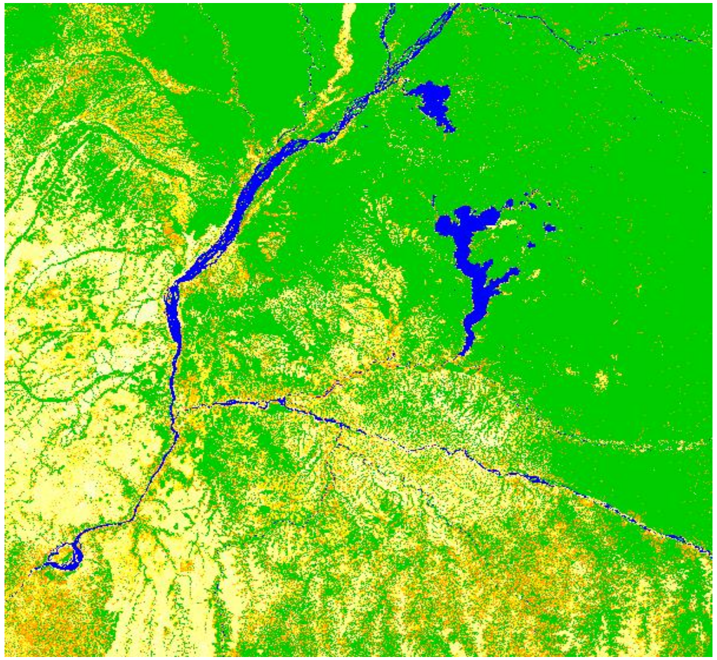
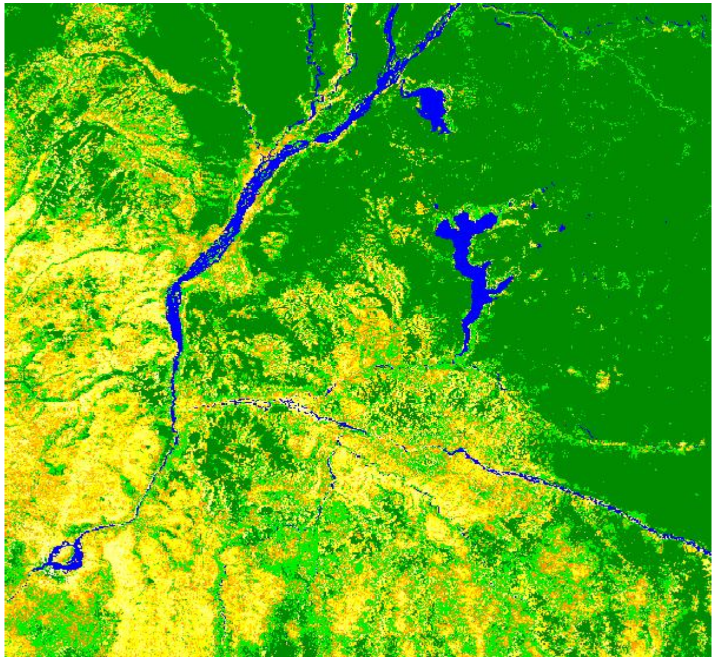
	10-20 Mg ha^{-1}		60-100 Mg ha^{-1}
	20-30 Mg ha^{-1}		> 100 Mg ha^{-1}
	30-40 Mg ha^{-1}		water
	40-50 Mg ha^{-1}		no data



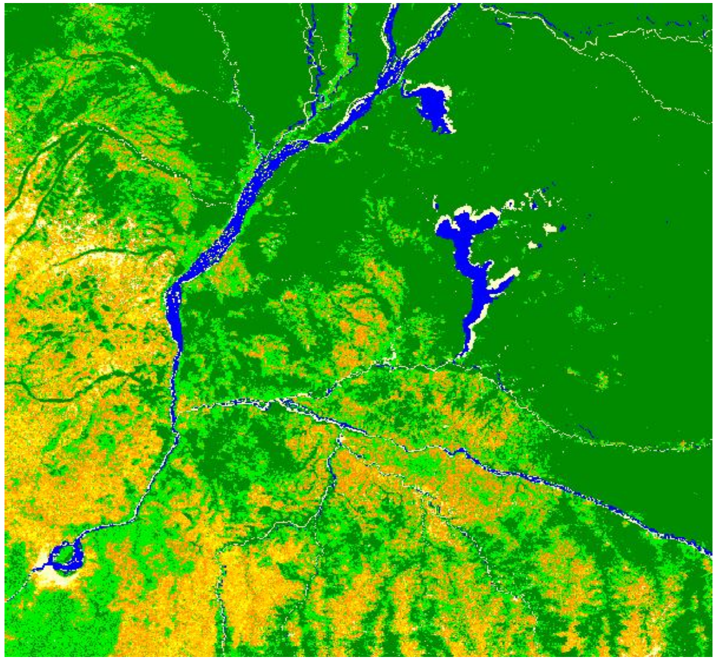
Comparison with existing maps



This study



Saatchi et al., 2011



Baccini et al., 2012

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	40-50 Mg ha^{-1}		no data

Latitude: 5° S to 0° N

Longitude: 15° E to 20° E

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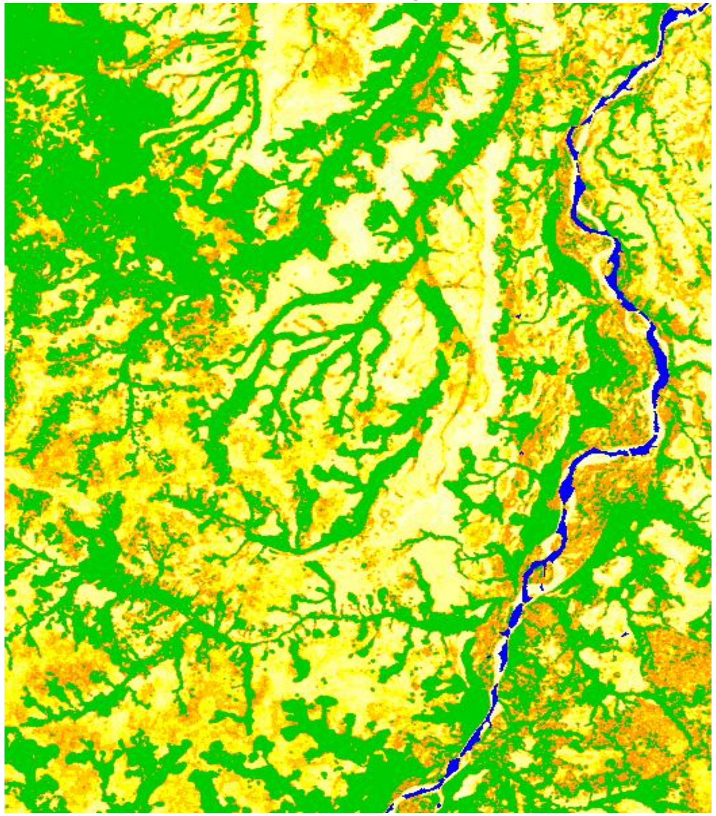
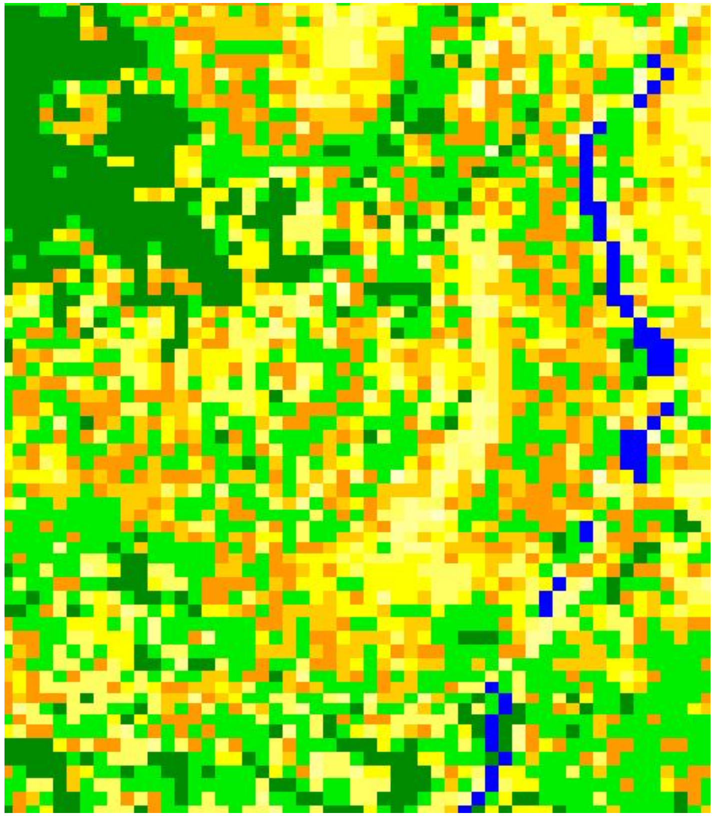
Comparison with existing maps

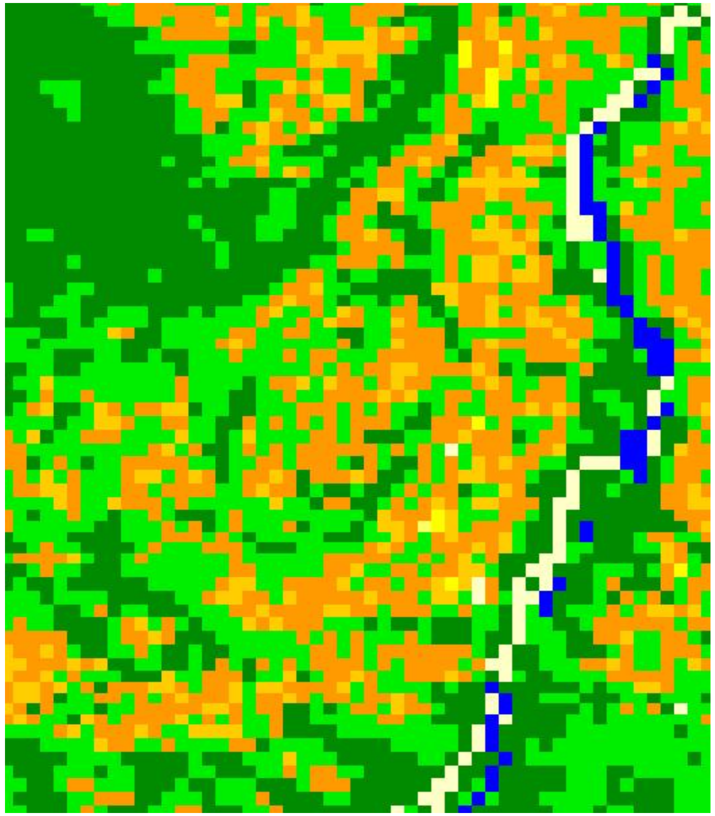
This study



Saatchi et al., 2011



Baccini et al., 2012



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	60-100 Mg ha^{-1}
	> 100 Mg ha^{-1}
	water
	no data

Subset from: Latitude: 5° S to 0° N
Longitude: 15° E to 20° E

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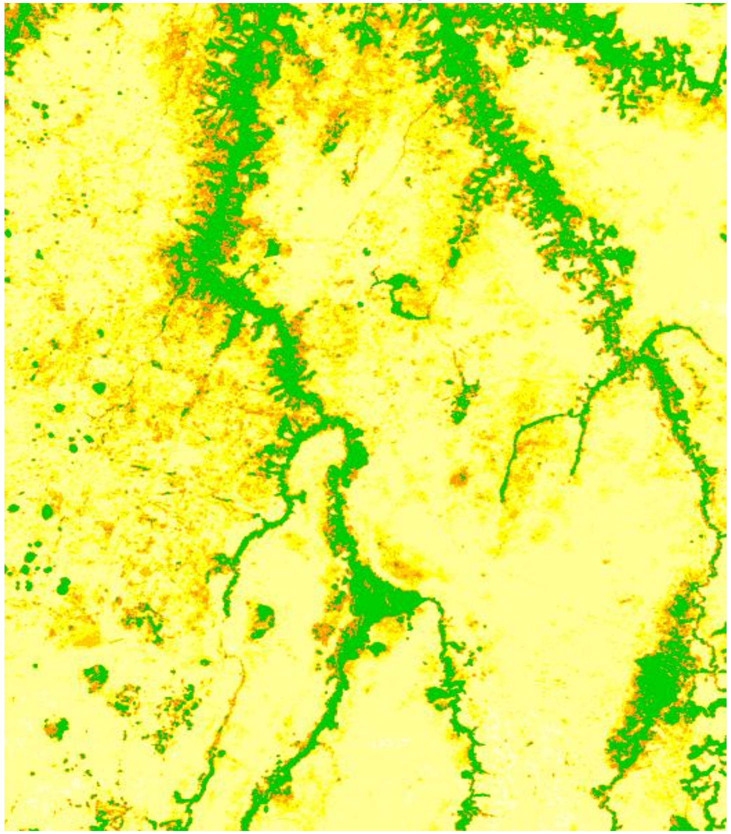
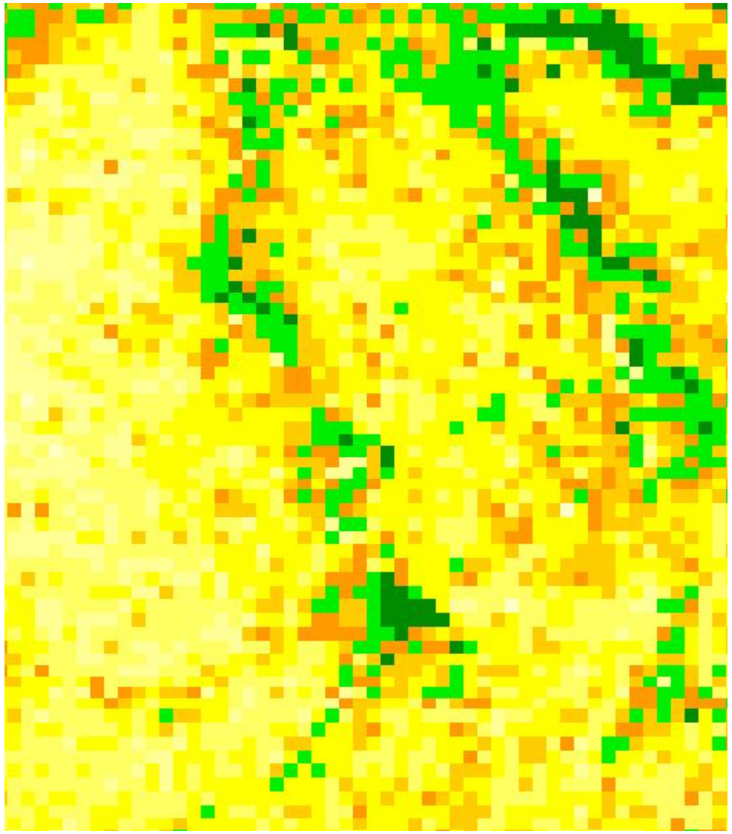
Comparison with existing maps

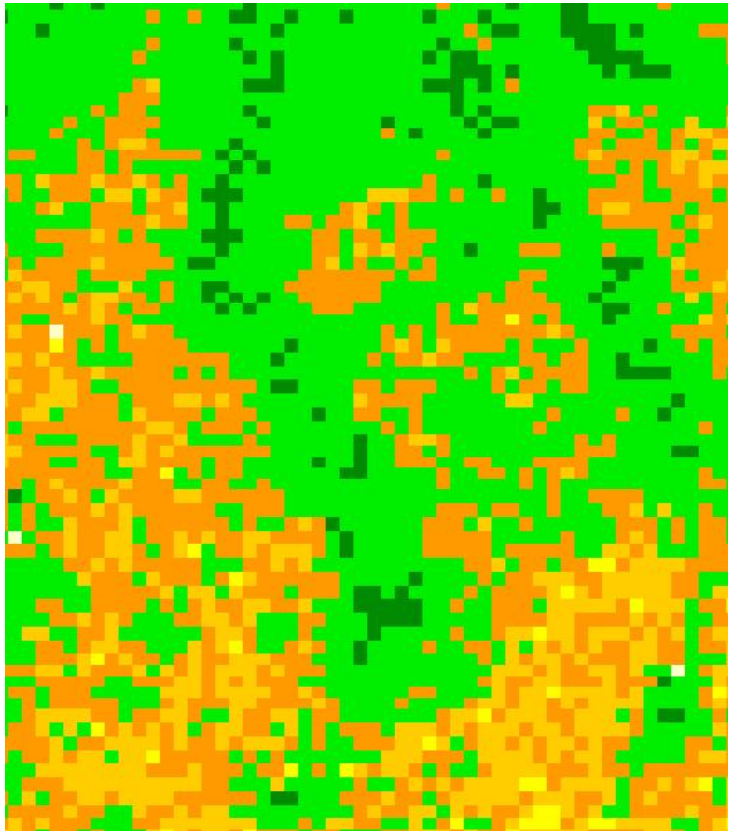
This study



Saatchi et al., 2011



Baccini et al., 2012



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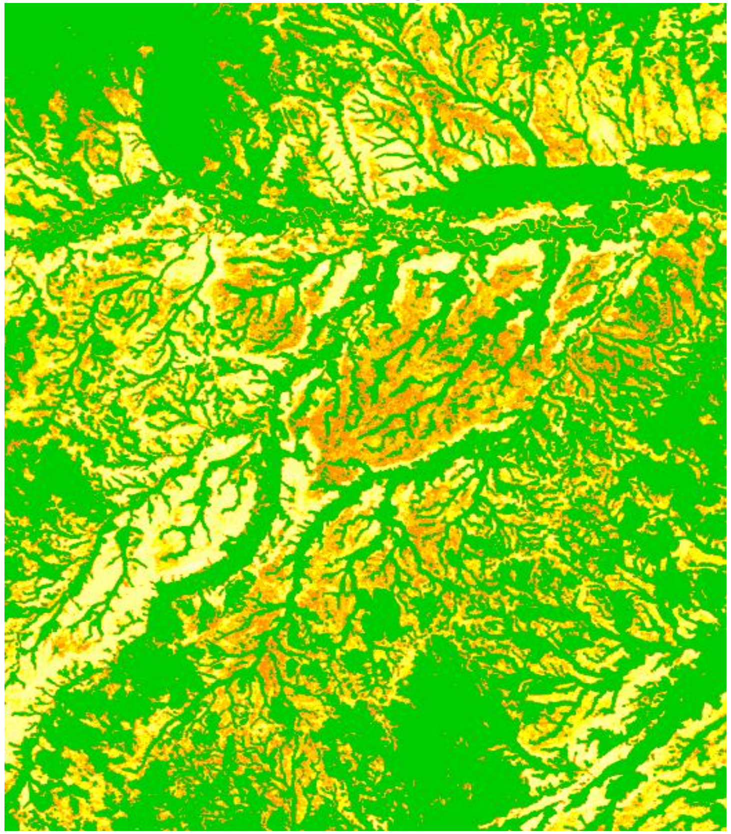
40-50 Mg ha^{-1}	no data

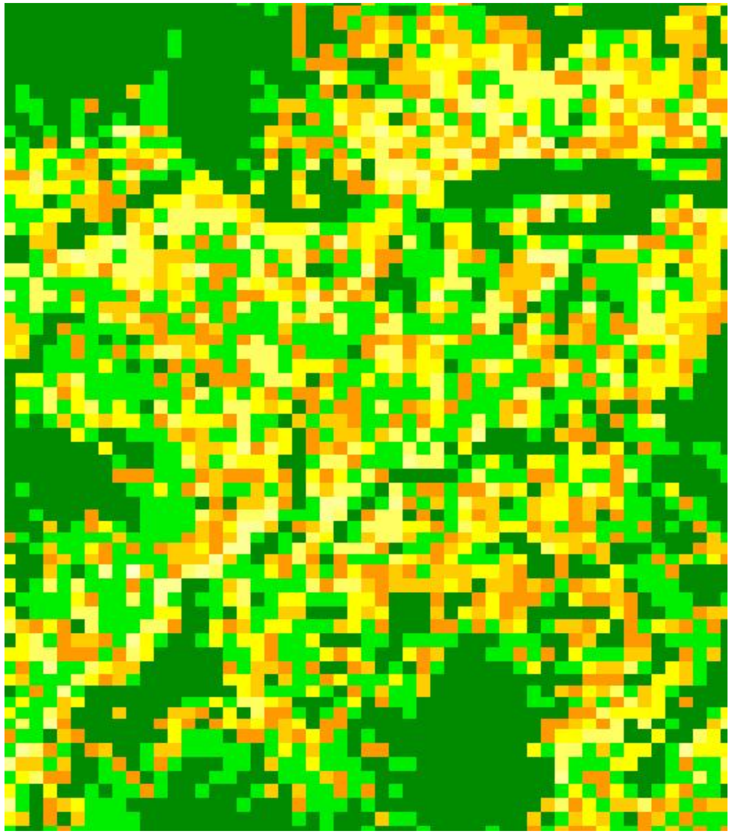
Subset from: Latitude: 5° S to 0° N
Longitude: 15° E to 20° E

Comparison with existing maps

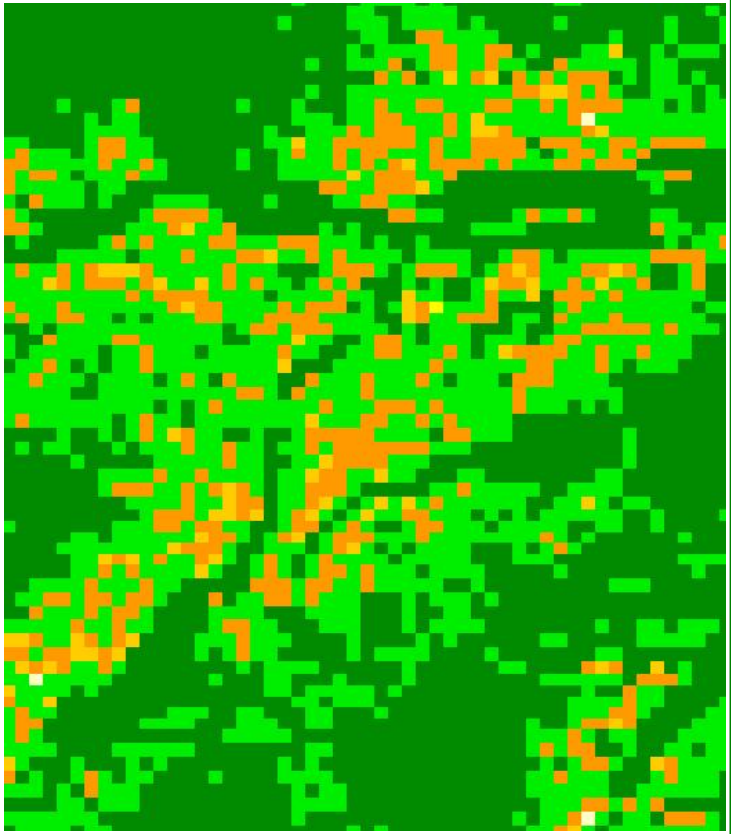
This study



Saatchi et al., 2011



Baccini et al., 2012



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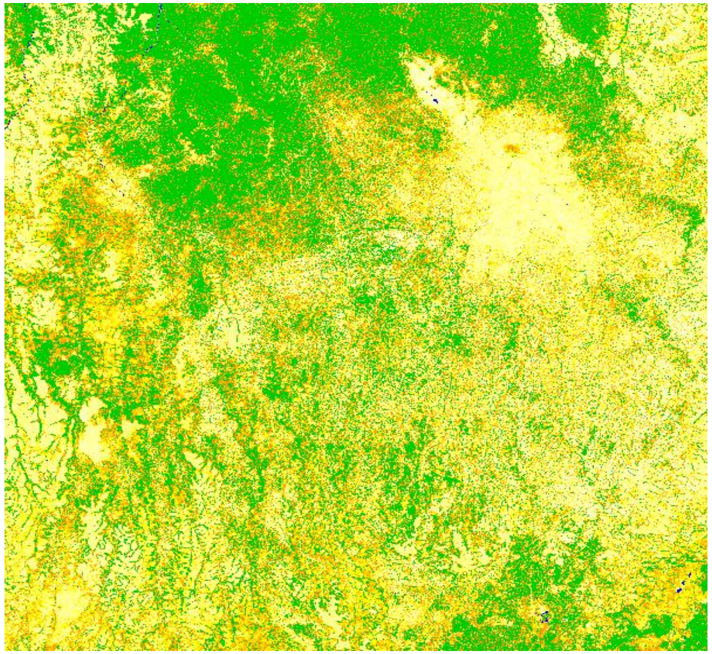
	30-40 Mg ha^{-1}
	40-50 Mg ha^{-1}
	50-60 Mg ha^{-1}
	60-100 Mg ha^{-1}
	> 100 Mg ha^{-1}
	water
	no data

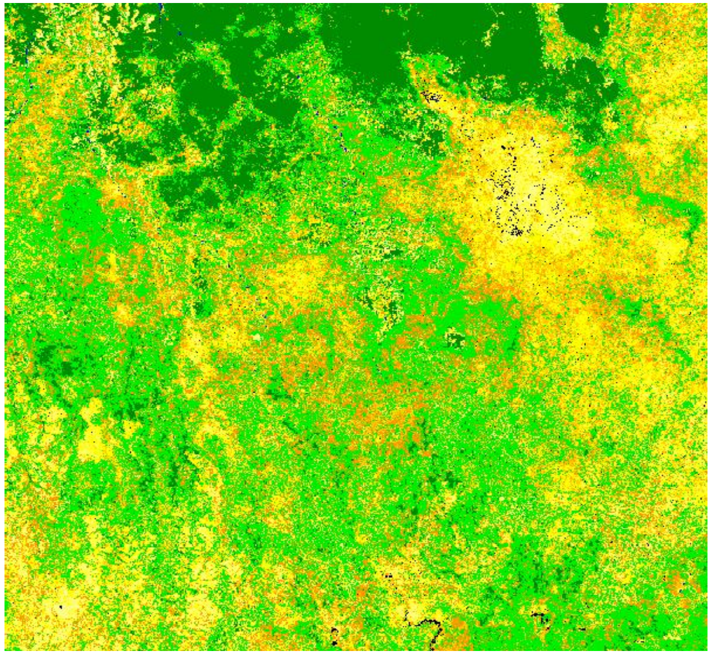
Subset from: Latitude: 5° S to 0° N
Longitude: 15° E to 20° E

Comparison with existing maps

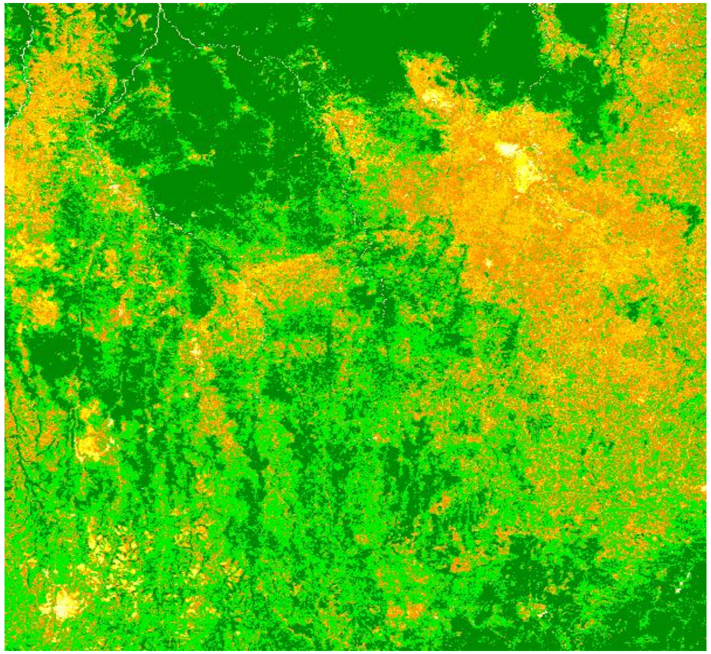
This study



Saatchi et al., 2011



Baccini et al., 2012



Latitude: 10° S to 5° S
Longitude: 20° E to 25° E

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	10-20 Mg ha^{-1}		60-100 Mg ha^{-1}
	20-30 Mg ha^{-1}		> 100 Mg ha^{-1}
	30-40 Mg ha^{-1}		water
	40-50 Mg ha^{-1}		no data

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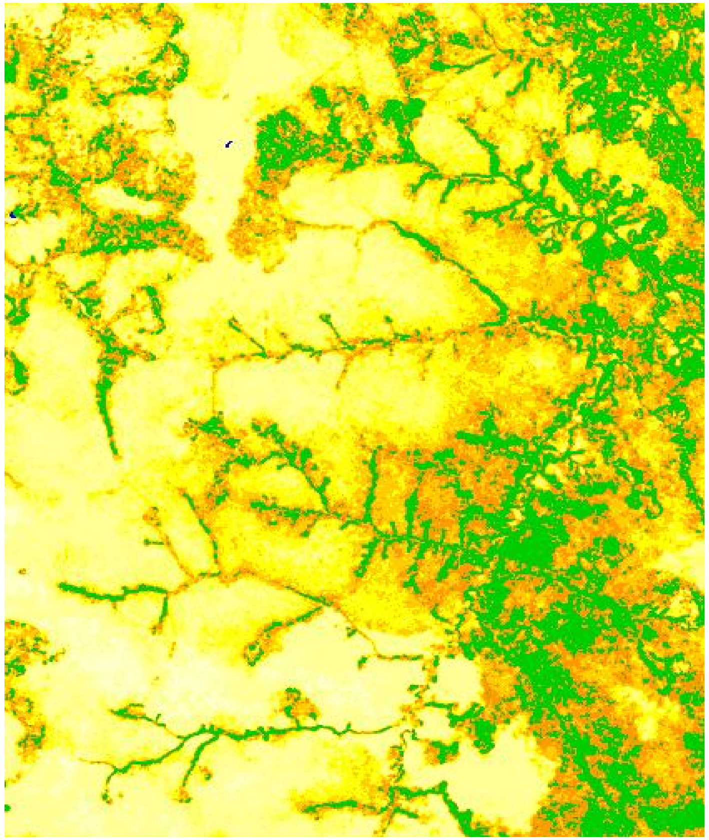
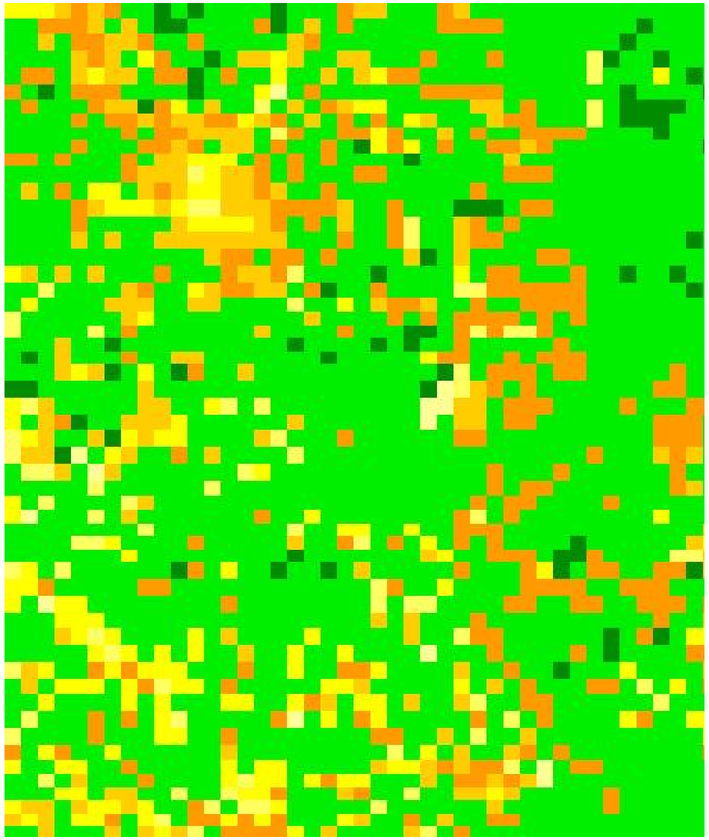
Comparison with existing maps

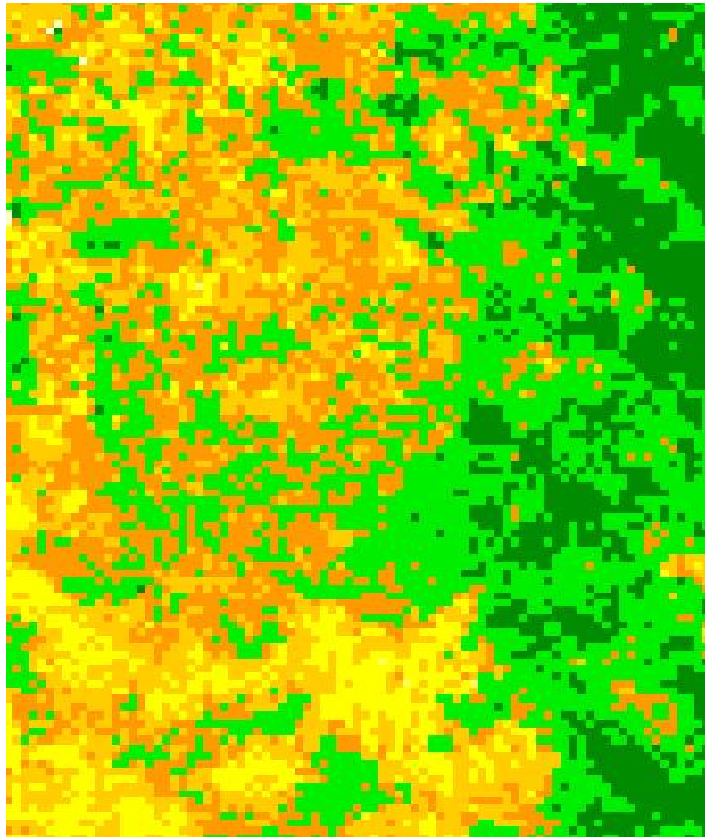
This study



Saatchi et al., 2011



Baccini et al., 2012



0-10 Mg ha^{-1}	50-60 Mg ha^{-1}
10-20 Mg ha^{-1}	60-100 Mg ha^{-1}
20-30 Mg ha^{-1}	> 100 Mg ha^{-1}
30-40 Mg ha^{-1}	water
40-50 Mg ha^{-1}	no data

Subset from: Latitude: 10° S to 5° S

Longitude: 20° E to 25° E

ALOS

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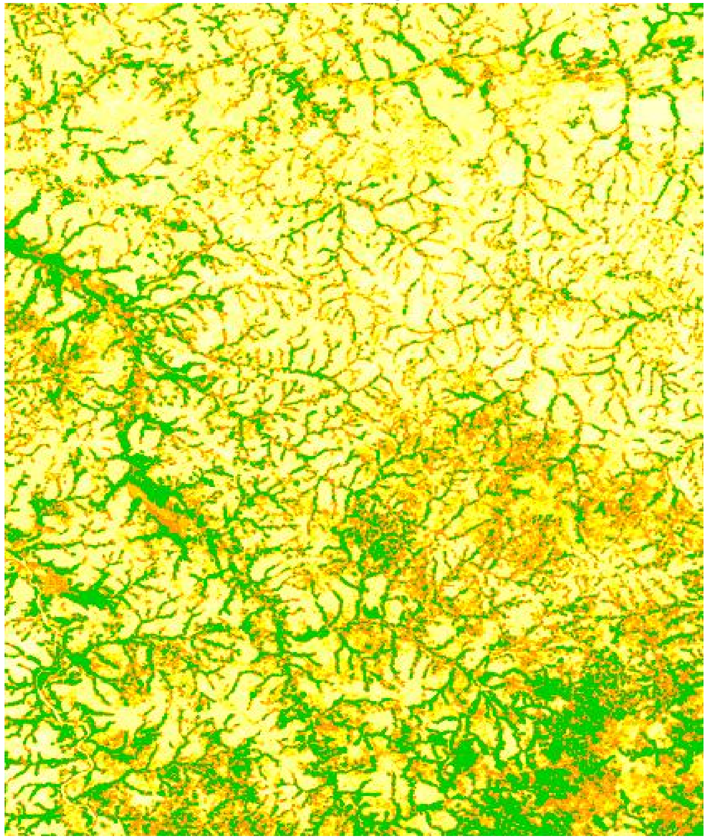
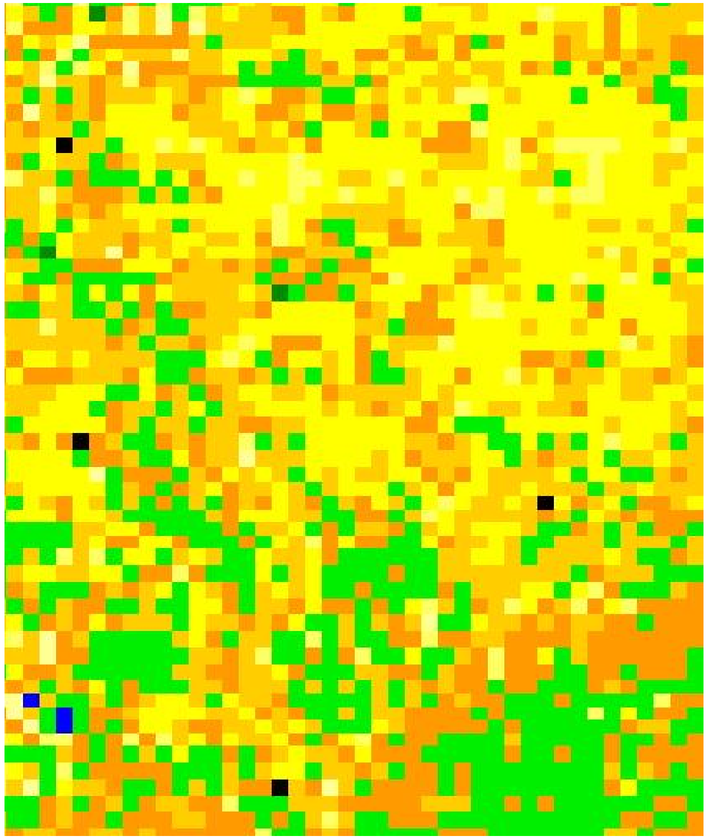
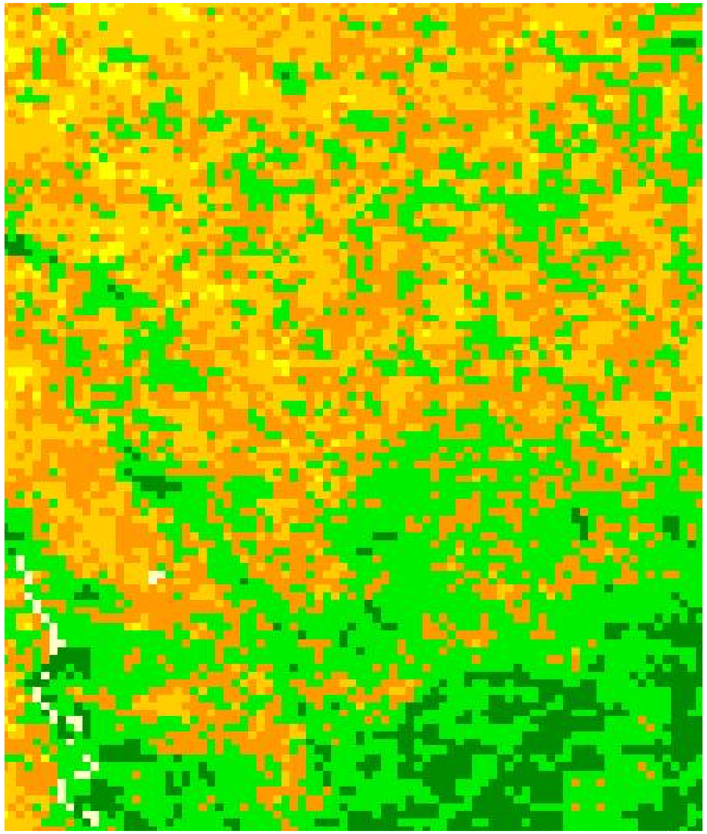


Saatchi et al., 2011



Baccini et al., 2012



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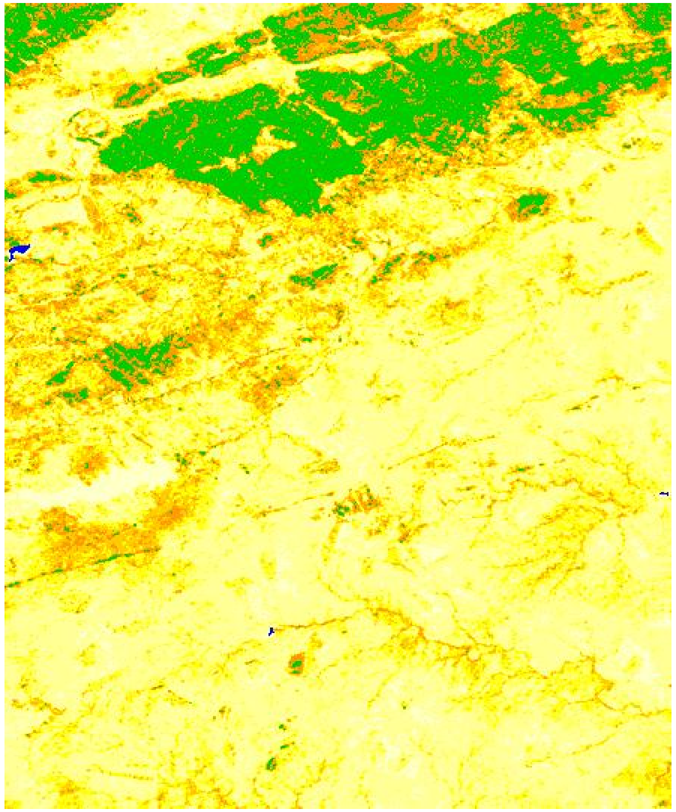
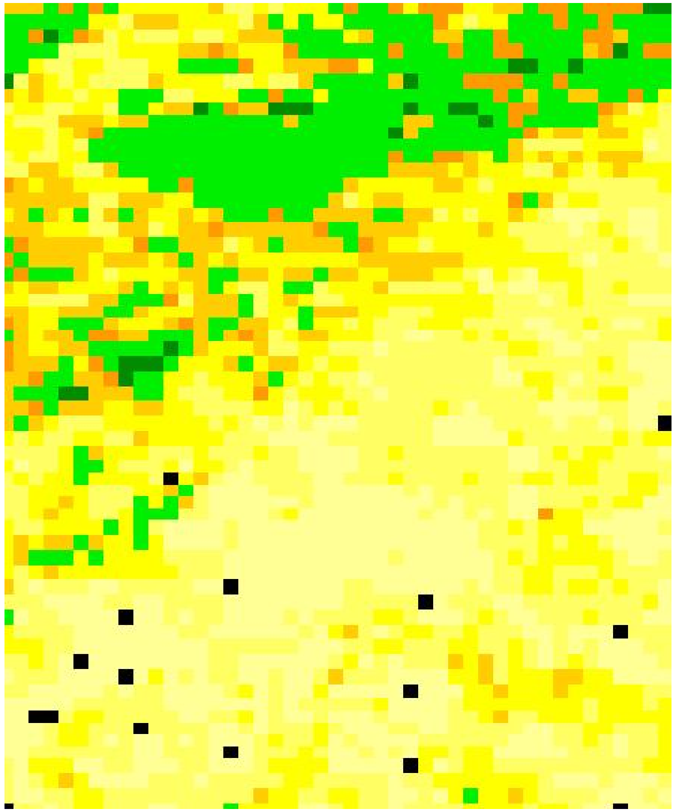
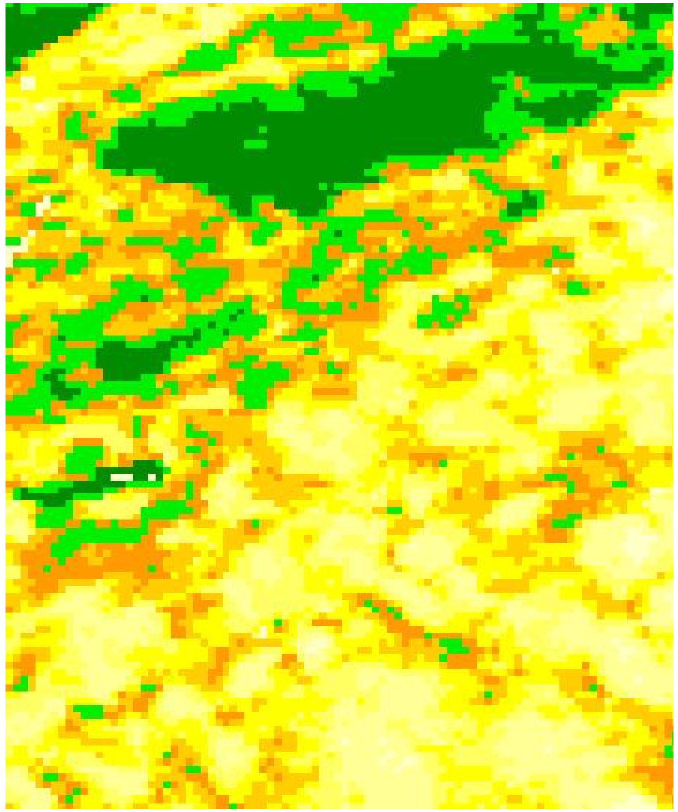


Saatchi et al., 2011



Baccini et al., 2012



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On the way to validation

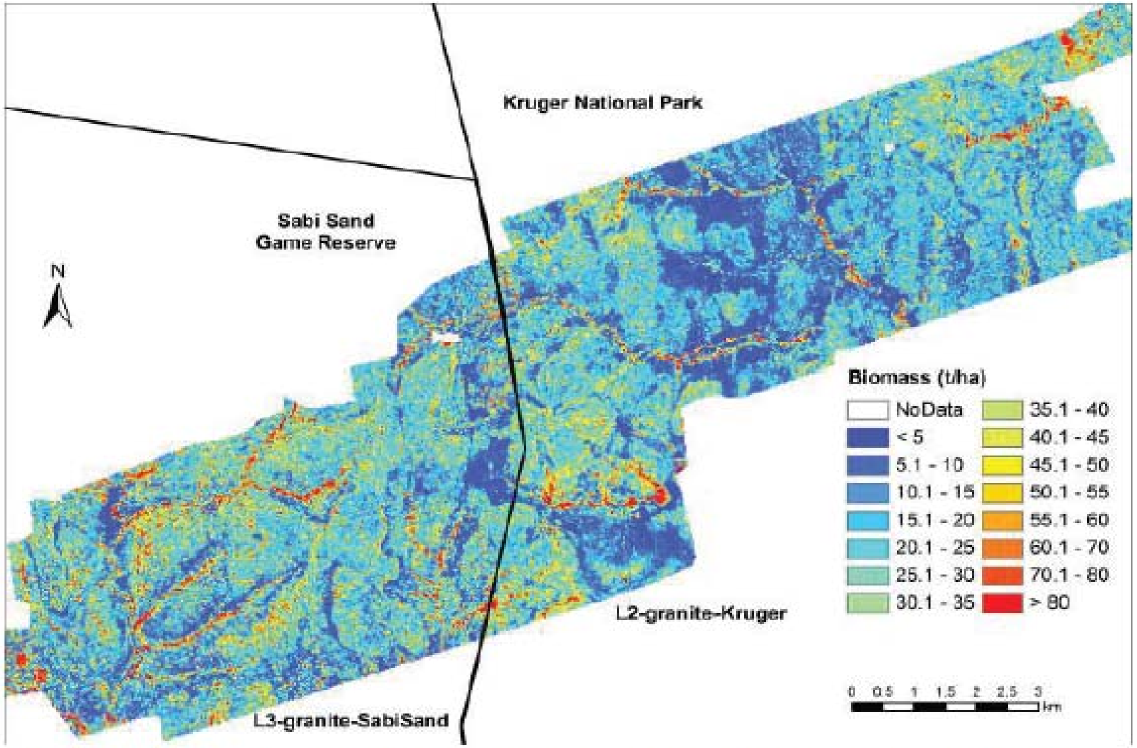
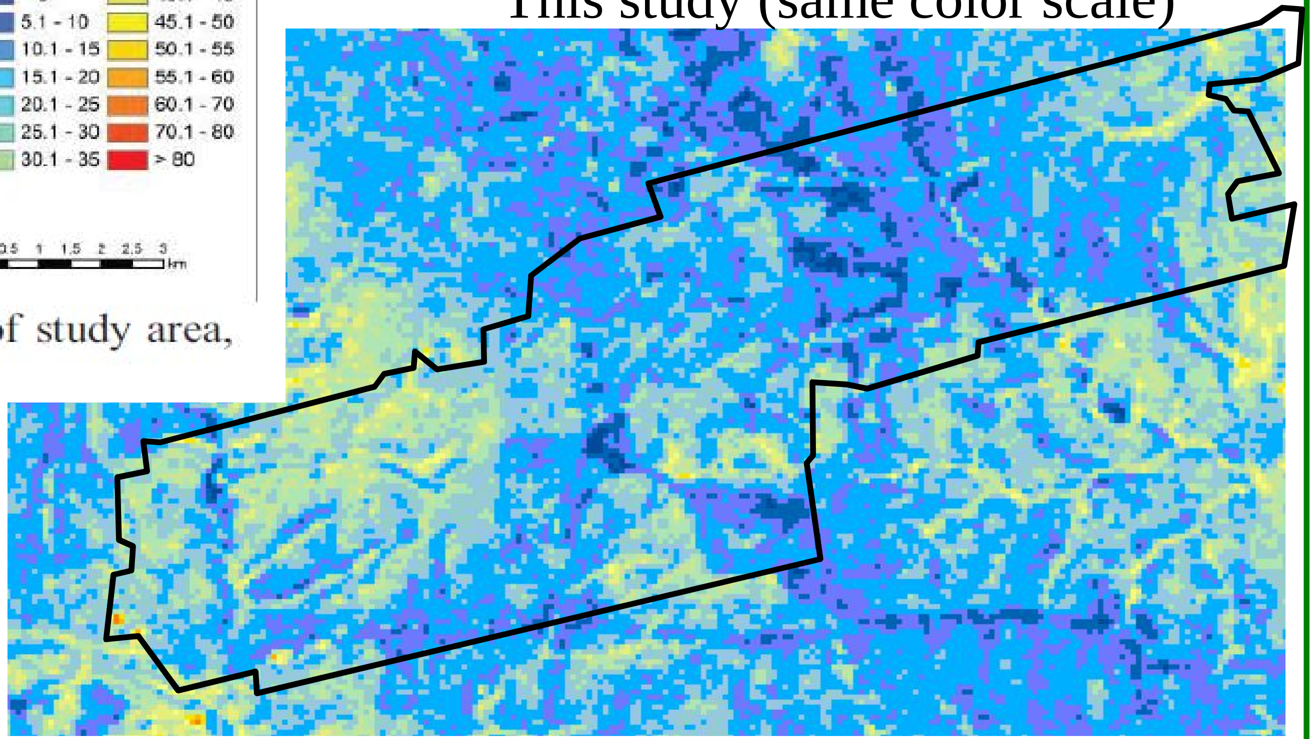


Fig. 1. LiDAR-derived biomass map for part of study area, L2, L3.

Wessels et al. IGARSS 2012

South Africa
24° 44’ S /
31° 36’E

This study (same color scale)



Conclusions and perspectives

• L-band data from PALSAR is adapted to large-scale mapping of biomass in savannas and woodlands, provided seasonality is taken into account.

• **Big limitation:** *In situ* data is missing to refine the methods and to validate the results.
Please help us find field plots bigger than 1 ha with a biomass between 0 and 100 Mg ha^{-1}!

• Recommendations for PALSAR-2: plan systematic acquisitions for the production of mosaics several times a year to capture the climatic variability over the two hemispheres.